BULLETINS

CEMENT-GUN COMPANY INC.

Allentown, Pa.

NEW YORK OFFICE:
30 CHURCH STREET

GUNITE

CEMENT-GUN COMPANY INC.

Building Construction

Including Specifications and Slab Tables

Reinforced "Gunite" on frame residence, Montecito, California. "Gunite" run moulding with a gun finish coat. Partially rodded "Gunite" base with irregular "Gunite" finish coat. Colored wash coat applied over finish coat.

THE "CEMENT-GUN" is not a restricted article and may be purchased and used by any one.

We also have a Contract Department which will be very pleased to give you estimates on any work that you may have.

CEMENT-GUN CO., Inc.
Allentown, Pa., U. S. A.

Bulletin 114-B
January, 1928

CEMENT-GUN
TRADE MARK

In Building Construction

'Gunite", the name given to the material composed of a mixture of sand and cement obtained by placing the mixture under high pneumatic pressure with a machine manufactured under the trade name "Cement-Gun", has been used very extensively in the last few years for various purposes, but in none more successfully than in the field of building construction.

"Stucco" over hollow tile, or over wood or metal lath, is used very largely in all sections of the country, but as usually interpreted stucco means a mortar of cement, or more generally cement and lime, placed by hand. The process of hand placing, where the "human element" so largely governs, has, through numerous failures due to lack of adhesion and to porosity, frequently brought "stucco houses" into very unfavorable criticism. "Gunite", however, due to its method of placing, is a mortar insuring positive adhesion to any applied surface; and, due to its density, insures a perfect protection against the passage of water.

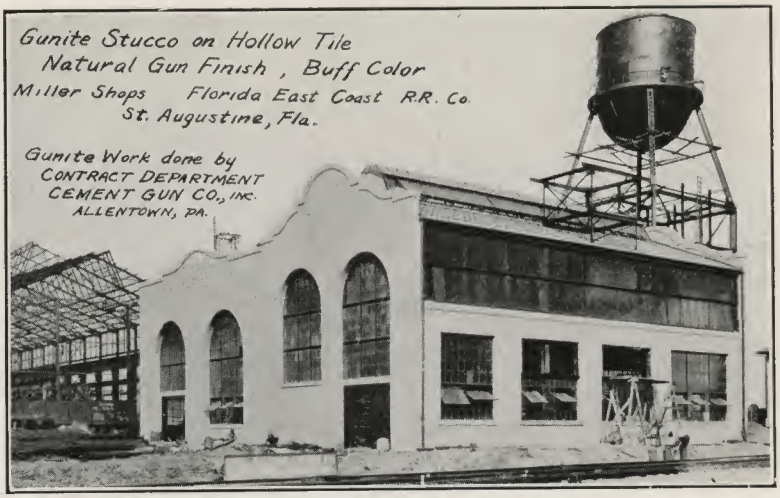


Fig. 1. Miller Shops, Florida East Coast Line R. R., St. Augustine, Fla. "Gunite" over hollow tile. Colored brush finish
(Work done by our Contract Department)

The positive adhesion is proven by numerous tests made under official supervision, but none more clearly shows it than one described in ENGINEERING NEWS RECORD of January 22, 1925, where a test made by the University of California to determine the adhesion of "Gunite" to concrete surfaces was described. In this test it was clearly brought out that the adhesion was much stronger than the shear value in the concrete itself, and could with safety be estimated at more than 600 pounds per sq. in. ultimate value.

The density of "Gunite" and its imperviousness is brought out in a statement made in the Transactions of the American Society of Civil Engineers Vol. LXXXI, Page 906 which reads as follows:—

> *"Some tests were carried out in the Laboratory of the University of California on the water tightness of plaster shot on the dam face with the "Cement-Gun." Several plaster slabs, from 5/8" to 1½" inches thick, made at Gem Lake, were tested with water pressure ranging from 700 feet to 1600 feet, for several hours, with no moisture coming through the slab. One 1 inch slab held a load of 1610 feet for 2½ hours without showing moisture, then the water pressure was raised gradually to 3400 feet and the specimen broke in bending, having leaked a little just before breaking."*

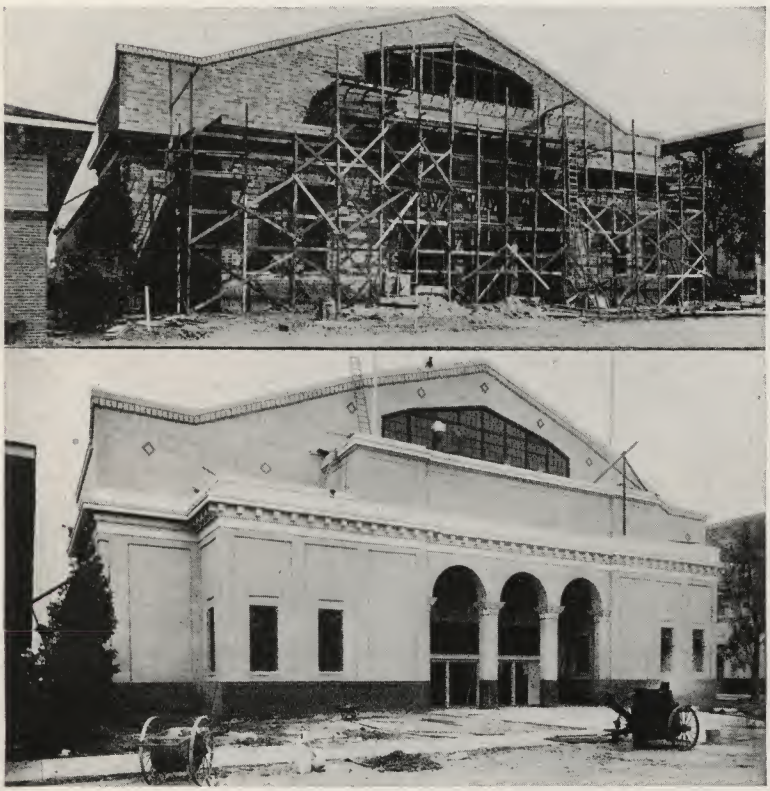


Fig. 2. Michigan State Fair Building, Detroit, Mich., "Gunite" over brick. Colored Brush Finish.
(Work done by our Contract Department)

Of equal interest is the high insulating values of thin "Gunite" slabs, and their high resistance to fire. Tests made at the Underwriters' Laboratories, in Chicago, showed that these thin slabs offered practically

perfect resistance to destruction from high temperatures, and comparison between these tests and similar tests made by the Bureau of Standards, in Washington, on brick walls is interesting. These tests showed that a brick-wall four inches thick resisted the passage of heat from a maintained temperature of 1700° F. on the exposed side, to 300° F. on the unexposed side, for one hour and twenty-six minutes, while the Underwriters' Laboratory report shows that a "Gunite" slab one and one-half inches thick resisted similar passage of heat for one hour and forty-four minutes.

For all the preceding reasons, therefore, "Gunite" is coming more extensively into use in building construction.

Fig. 3. Storage House at Billings, Montana, before being covered with "Gunite." The mortar joints were badly eroded and the building was in serious need of repair.

Fig. 4. After ½" coating of "Gunite", using white Portland Cement, had been placed. Two weeks after completion this building went through an earthquake without cracking, and the owner states that in his opinion the "Gunite" coating saved the building.

(Contractor, Security Bridge Co., Billings, Montana.)

Fig. 5. Buffalo International League Baseball Park, Buffalo, N. Y. Hand placed stucco removed and reinforcing mesh in place prior to applying "Gunite."

Fig. 6. Buffalo International League Baseball Park, Buffalo, N. Y. Finished "Gunite". Natural "Gunite" Finish.

(Work done by our Contract Department)

One of the best illustrations of the successful use of "Gunite" over hollow tile and concrete is in the construction of the California Palace of the Legion of Honor, in Lincoln Park, San Francisco. This work was described in the PACIFIC COAST ARCHITECT of December, 1924. "Gunite" was used on account of the positive assurance of permanency and its weather resisting and water resisting qualities.

Fig. 7. California Palace of the Legion of Honor, Lincoln Park, San Francisco.
"Gunite" over concrete and hollow tile. Hand placed finish coat,
Caen Stone Imitation.

Fig. 8. Los Angeles Public Library, Los Angeles, Calif.
"Gunite" over concrete.
(Work done by Los Angeles Cement-Gun Co., Los Angeles, Cal.)

Figure 9. Brick building in Meriden, Conn., before "Gunite" was applied. Note the method of placing strips around windows to obtain true lines.

Figure 10. Above building after being "Gunited"

The above work was done by the Traylor-Dewey Contracting Company (now our Contract Department), in 1920.

"GUNITE" OVER EXISTING WOODEN STRUCTURES

"Gunite" has been used extensively as a method of protecting existing "frame" structures against fire and also against the need of painting maintenance. An early illustration of this was the former residence of Mr. L. D. Baldwin, at East Orange, N. J. This was covered with "Gunite" in 1912, and in 1923 when the building was torn down it was found that the "Gunite" slabs were so strong that it was necessary to remove them in sheets, and that the reinforcing mesh showed no signs of corrosion.

Figure 11. Office Building, Dexter Portland Cement Company, Nazareth, Pa., showing old wooden siding, also reinforcing mesh in place, and completed "Gunite".

(Work done by our Contract Department)

Such method of construction has been largely adopted by the N. C. & St. L. Railway, and published reports state that the saving in painting paid for the cost of the "Gunite" in six years. This, in addition to reducing the fire hazard and making the buildings more resistant to heat and cold.

A remarkable illustration of the success of this method of protection is that of the buildings of the Bunker Hill Smelter in Idaho. As a result of protecting these frame buildings with one inch of "Gunite" it is reported to us that the insurance companies have allowed a reduction of insurance rates from $1.52 to $1.17 thereby saving $12,000 per year.

RESIDENCE WALL CONSTRUCTION

In the direct construction of the walls of cottages and industrial buildings "Gunite" is now meeting with the greatest success and we show herein practical and established methods for such construction.

"GUNITE" WALLS OVER WOODEN FRAME.

The most extensively employed method in residence construction by the use of "Gunite" is shown in general detail in Figure 13 which illustrates a type of dwelling adopted by the American Bauxite Company. A fire test was made on such a wall by the Underwriters' Laboratories, and in reporting on the test the statement is made:—

"The tests indicate that the construction will not allow flame passage provided the "Gunite" is given a chance to expand."

As the entire stability and the life of "Gunite" walls depends upon the care used in choosing and placing the reinforcement it will be necessary to follow these few rules:

(a) Use a sufficiently heavy reinforcement.

(b) Do not attach too closely to supporting members.

(c) Lap all adjacent sheets at least four inches and firmly tie together.

(d) Bend mesh over template to fit corners. Do not spring sheets around corners.

(e) Fasten additional sheets of mesh (about 9" x 24") diagonally across the corners of all openings. This is especially necessary as a preventive against diagonal cracking at this point of weakness.

It is urged by some engineers that it is desirable to reinforce the opening by a hooped rod entirely surrounding it.

Fig. 12. Administration Building, Pioneer Paper Co., Los Angeles, Cal.
STRUCTURE: Wood frame with reinforced "GUNITE" walls
MOULDINGS: "GUNITE" 'run' and blocked off.
LINTELS AND BRACKETS: Hand carved "Gunite."
FRIEZE: 'Sacked' "Gunite" jointed like tile.
BODY OF BUILDING: Irregular "GUNITE" steel trowelled.
FOUNDATION: 'Sacked' "GUNITE" marked like stone
(Work done by Los Angeles Cement-Gun Co., Los Angeles, Cal.)

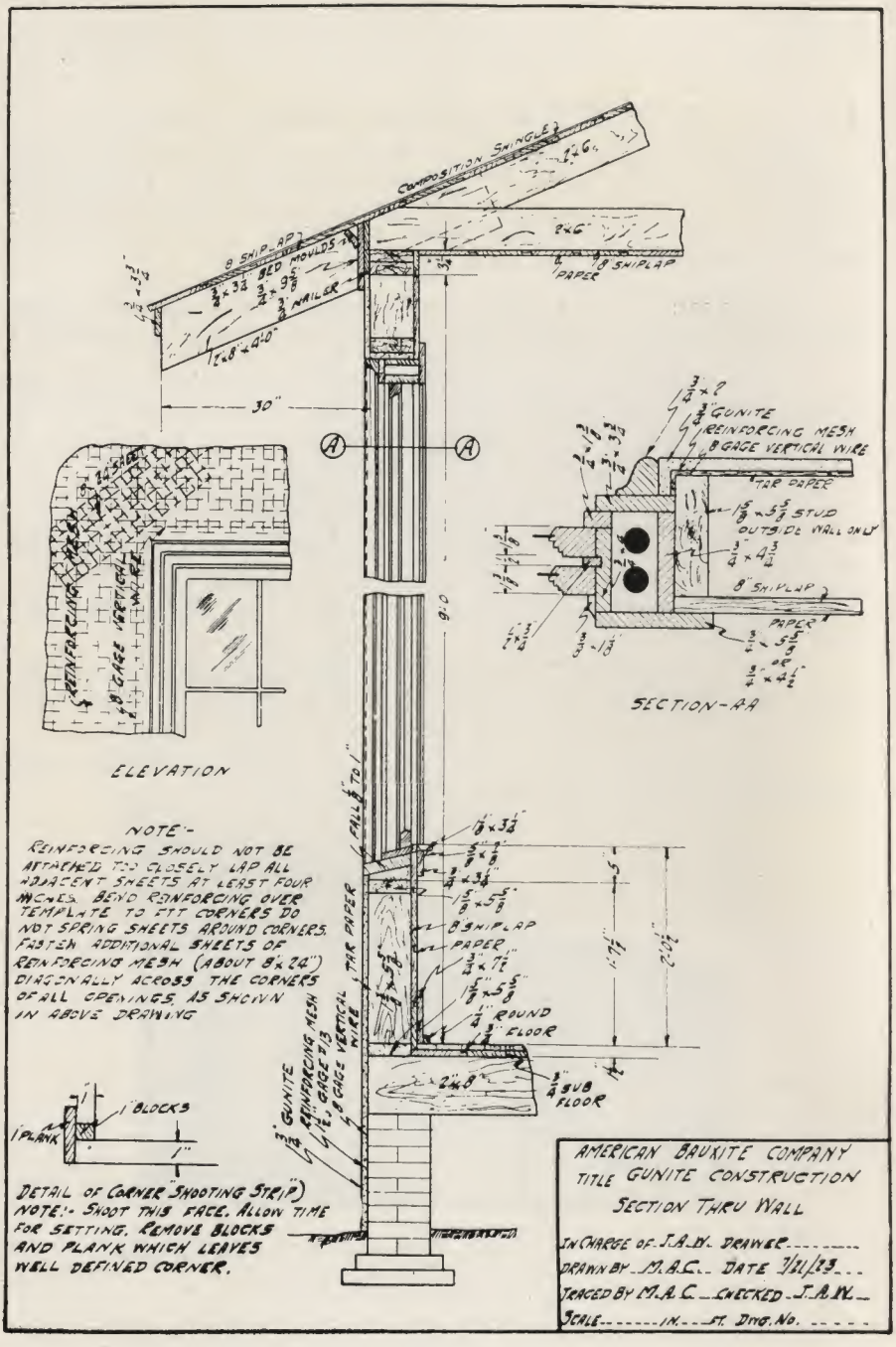

COMPOSITION SHINGLES
8 SHIP-LAP
BED MOULDS
NAILER
2×6
PAPER
8" SHIPLAP
30"
A
A
REINFORCING MESH
8 GAGE VERTICAL WIRE
ELEVATION
GUNITE
REINFORCING MESH
8 GAGE VERTICAL WIRE
TAR PAPER
STUD
OUTSIDE WALL ONLY
8" SHIPLAP
PAPER
SECTION-A-A
9'-0"
FALL 1/4" TO 1'
TAR PAPER
8" SHIPLAP
PAPER
ROUND
FLOOR
SUB FLOOR
2'-6"
NOTE:-
REINFORCING SHOULD NOT BE ATTACHED TOO CLOSELY LAP ALL ADJACENT SHEETS AT LEAST FOUR INCHES. BEND REINFORCING OVER TEMPLATE TO FIT CORNERS DO NOT SPRING SHEETS AROUND CORNERS. FASTEN ADDITIONAL SHEETS OF REINFORCING MESH (ABOUT 8×24") DIAGONALLY ACROSS THE CORNERS OF ALL OPENINGS AS SHOWN IN ABOVE DRAWING
1 BLOCKS
1 PLANK
DETAIL OF CORNER SHOOTING STRIP)
NOTE:- SHOOT THIS FACE. ALLOW TIME FOR SETTING. REMOVE BLOCKS AND PLANK WHICH LEAVES WELL DEFINED CORNER.
GUNITE
REINFORCING MESH
8 GAGE VERTICAL WIRE
AMERICAN BAUXITE COMPANY
TITLE GUNITE CONSTRUCTION
SECTION THRU WALL
IN CHARGE OF J.A.N. DRAWER
DRAWN BY M.A.C. DATE 3/21/23
TRACED BY M.A.C. CHECKED J.A.N.
SCALE IN. FT. DWG. NO.

Figure 13.

Figure 14. Tar paper, mesh, and corner strips in place.

Figure 15.
Completed Buildings.

Group of workmen's cottages constructed as per details on page 10.
(Work done by our Contract Department)

"Gunite" walls are susceptible to different types of surface treatment in exactly the same manner as are hand placed mortar walls.

None of the so called waterproofing compounds should be used in the mixture. "Gunite" is water proof without them.

Cost and speed naturally enter into the consideration of any construction and a comparative estimate is hereby given between such a wall and the wall of an ordinary sheathed and sided house so generally used in the United States. As the frame work for either type would be identical the comparison will start from this point.

Estimated Cost of Sheathed and Sided Wall per sq. ft.

Sheathing, with lumber at $40.00 per M.	.040 per sq. ft.
No loss of waste estimated.	.000 per sq. ft.
Carpenters placing sheathing at $20.00 per M.	.020 per sq. ft.
Building paper to cover sheathing	.005 per sq. ft.
Placing building paper	.005 per sq. ft.
Siding at $100.00 per M.	.100 per sq. ft.
Loss due to waste and lap	.020 per sq. ft.
Carpenters placing siding at $40.00 per M.	.040 per sq. ft.
Nails, etc.	.005 per sq. ft.
Painting 3 coats	.070 per sq. ft.
Total, exclusive of overhead, supervision, scaffold or profit	.305 cents per sq. ft.

In addition to this should be added a maintenance charge as it will be necessary to paint with at least two coats every two years in order to properly preserve the house. There should also be added a charge due to increased insurance rates over a house with "Gunite" walls **which should cost as follows**:*

Horizontal wires (if used) behind tar paper		.005 per sq. ft.
Tar paper		.020 per sq. ft.
Placing tar paper		.010 per sq. ft.
Reinforcing mesh		.040 per sq. ft.
Placing mesh		.020 per sq. ft.
Lap and nails		.005 per sq. ft.
Placing corner shooting strips and window strips		.010 per sq. ft.
"Gunite" Materials 1 to 3—		
1 bag Cement	$ .75–	
3 cu. ft. sand	.25–$1.00	
will cover 20 sq. ft. 1" thick or $\frac{100}{20}$ =		.050 per sq. ft.
One nozzleman	$8.00 per day	
One nozzleman assistant	3.50 per day	
One Gun Operator	5.00 per day	
4 Laborers mixing and handling, also moving portable scaffolds, at $3.50	14.00 per day	
One Compressor runner	6.00 per day	
One Finisher	12.00 per day	
Total	$48.50 per day	
Will average a minimum of	1300 sq. ft. each day	.037 per sq. ft.
Plant depreciation	$13.00 per day	.010 per sq. ft.
Power	10.00 per day	.008 per sq. ft.
Repairs and renewals	6.00 per day	.005 per sq. ft.
Cleaning up	13.00 per day	.010 per sq. ft.

Making the total cost, exclusive of overhead, supervision, scaffold or profits and with standard "Gunite" stipled finish, of .23 cents per sq. ft. for a wall which is fireproof and free from maintenance, as well as weatherproof and of perfect insulation.

A substantiation of these figures was contained in a letter giving bids on individual buildings at San Diego, Cal., of $2.00 per sq. yd.

*NOTE—*In drawing comparisons please substitute local costs of labor and materials to suit.*

Figure 16. Wood frame, tar paper backing, and reinforced "Gunite". Note the highly decorative effects obtained in shooting the cornices, mouldings, pilasters, etc., directly in place

Figure 17. Wood frame, tar paper backing, and reinforced "Gunite".

Figure 18. Wood frame, tar paper backing and reinforced "Gunite". Note the brick corner and window trim

(Work done and photographs furnished by Los Angeles Cement-Gun Co., Los Angeles, Cal.)

Fig. 19. Stadium of Leland Stanford University. "Gunite" slabs over light frame. This highly illustrates the architectural effects which can be obtained with a light, economical and permanent construction.
(Work done by Cement-Gun Construction Co. of Calif.)

Figure 20. Residence of Kenyon Riddle, West Palm Beach, Florida. "Gunite" walls over wooden frame, 'sacked' finish.
(Work done by our Contract Department)

"GUNITE" FIRE RESISTING HOUSES.

Numerous efforts are being made to develop a type of residence construction which will be economical; which will be more permanent and fire resisting than wooden frame; more substantial than hollow tile; more weather resisting than concrete; and as "fireproof" as brick, and toward that end the construction shown below has been devised. It will be noted that the walls consist of monolithic "Gunite" studs, girders, and slabs shot against light panel forms which are left in place.

Economy naturally results when these panels are made as uniform in dimension as possible. They are made of such heights that the top of the panel becomes a form on top of which is built up the "Gunite" connecting girders which act as supports for the upper floors and roof. These girders form a belt course around the house, preventing cracks, and at the same time serve as an ABSOLUTE fire stop. In setting up the panels they are spaced in such a manner as to leave a recess or pocket between them, and the "Gunite" that is shot into this pocket forms the supporting stud. The form panels are preferably designed in such a way that when the connecting board between the adjacent panels, forming the backing for the stud, is placed, it is on a plane with the light intermediate vertical wood members. In this manner a support is immediately prepared for the interior plaster.

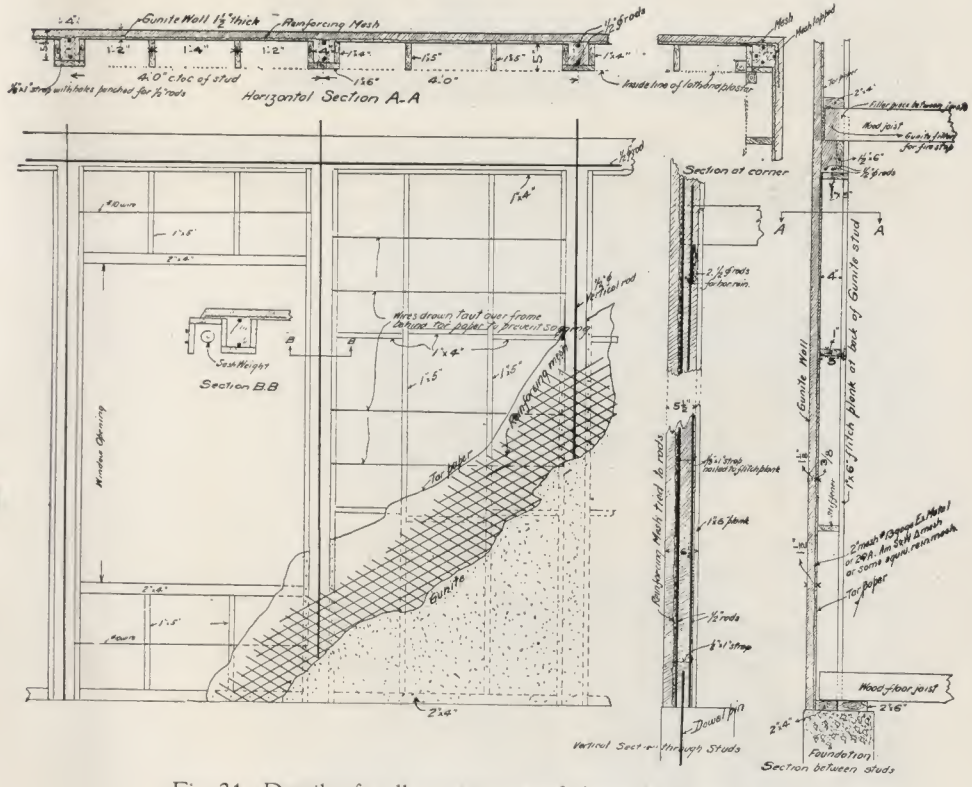


Fig. 21. Details of wall construction of above described house.

Figure 22

Showing form panel being placed. Note the ease with which one man handles a panel.

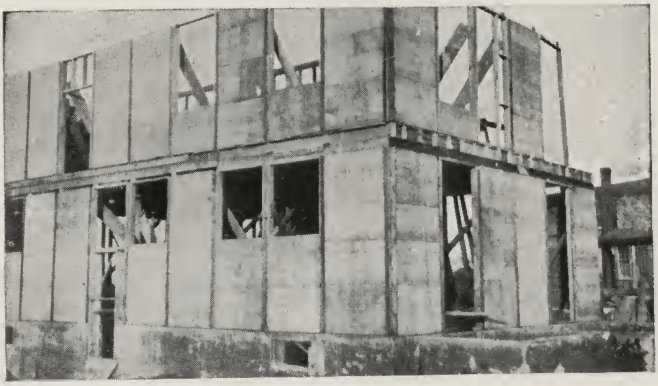


Figure 23

Forms in place showing recesses for studs and girders.

Figure 24

Forms complete with mesh and rods in place prior to "Guniting."

Figure 25

Completed building

Building described on page 15. Erected 1919 and is in perfect condition today.

INDUSTRIAL BUILDINGS.

While "Gunite" walls have met with marked success in residence construction the use of "Gunite" in the construction of walls and roofs of industrial buildings has been even more extended. The most generally adopted construction is that of a steel frame building with supporting members so spaced that the span of the slabs shall not exceed eight feet, but "Gunite" walls can be as successfully placed over reinforced concrete frame.

To insure proper and ecomonical construction of "Gunite" walls over steel frame it is advisable to design the steel in such manner that the outer face of all supporting members will be in the same plane and with uniform spacing to reduce the cost of form work to a minimum. Details as developed in the office of Albert Kahn, Inc., Architects, Detroit, Mich., are shown on Page 18.

The steel should be punched at about three feet to four feet spacing to allow the attaching of a rod, which rod will act not only as a member to which the mesh can be tied, but also as a furring strip to keep the mesh away from the steel. Such a wall is usually built by shooting against portable wooden panels or forms, and therefore, as stated above, care should be taken when designing to space all supporting members as nearly equally as possible in order to eliminate frequent cutting up of these panels.

For general specifications see Page 37.

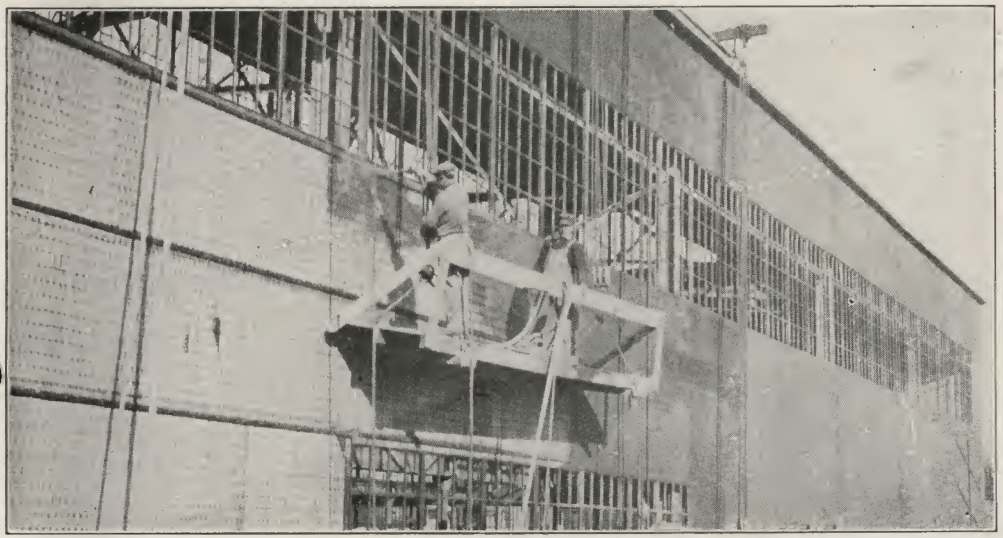


Fig. 26. Building side walls of Illinois Steel Company Plant, at South St. Paul, Minn. Work done about 1914.

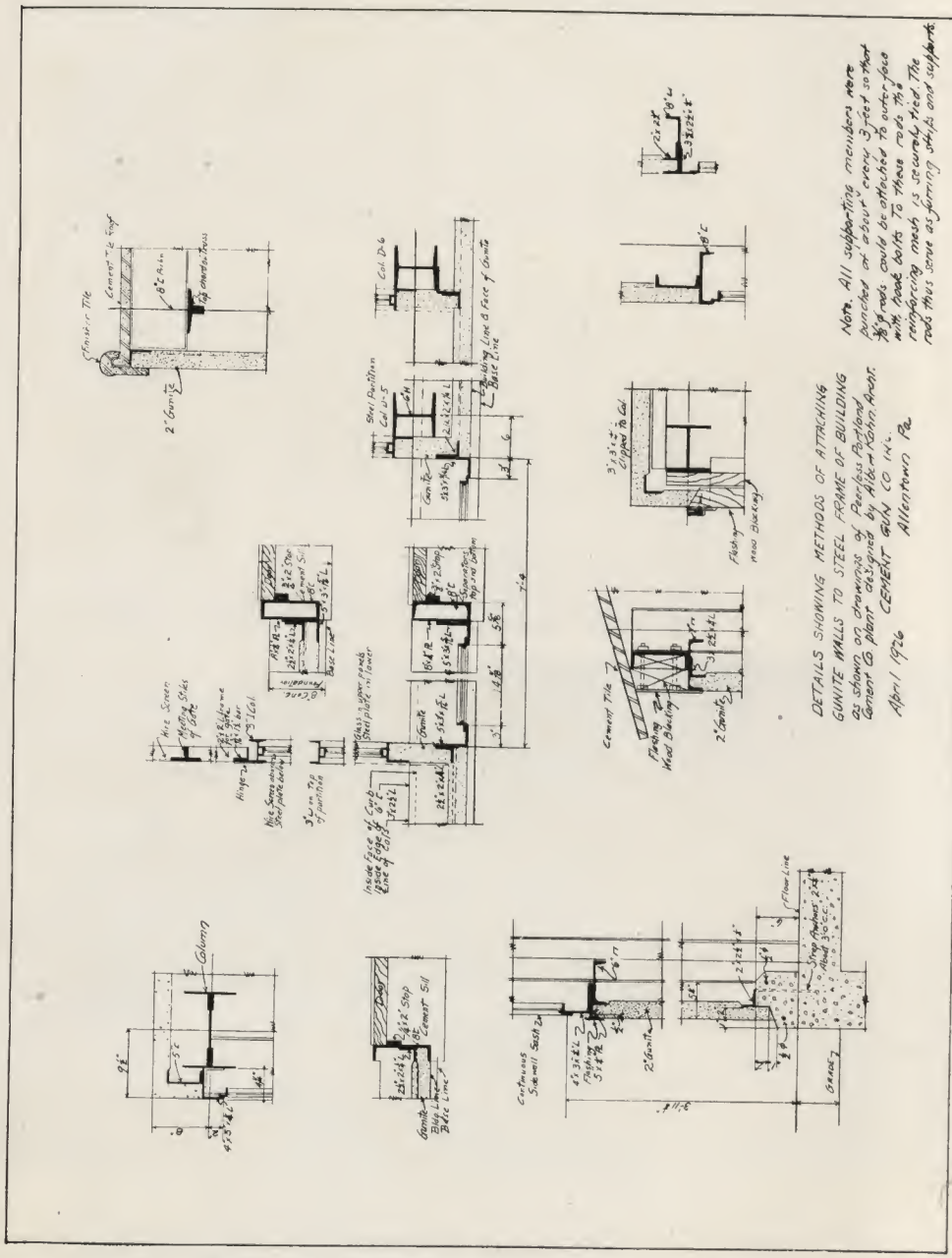


Fig. 27. Steel details for buildings with "Gunite" walls.

Figure 28. Shibe Park, Philadelphia, Pa. Two-inch "Gunite" walls over steel frame.
(Work done by our Contract Department)

Figure 29. Building at plant of New York Ship Building Company, Camden, N. J. Built in 1918. "Gunite" walls over steel frame.
(Work done by our Contract Department)

Figure 30. Showing steel frame, roof already shot, second floor being shot

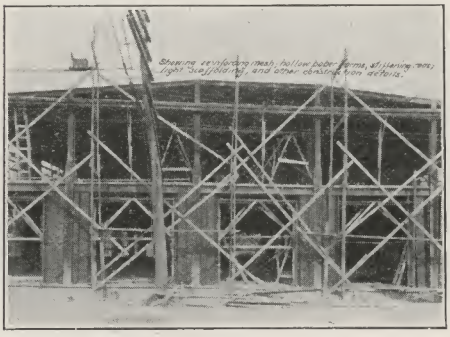
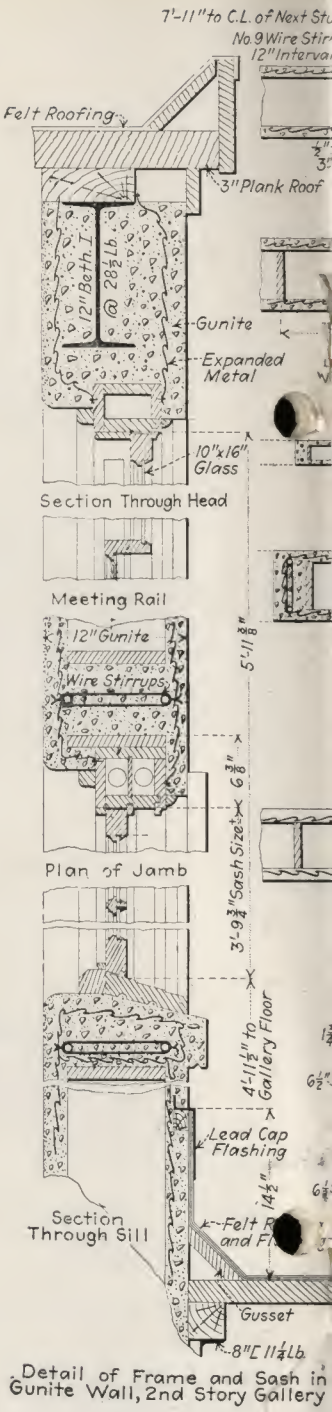


Figure 31. Showing details of paper forms for hollow wall construction, also rods and mesh in place

Figure 32. Showing fireproofing of columns and girders

Figure 33. Showing completed building. Note the panelling.
(Work done by our Contract Department)



Photographs at left show construction of a building with steel frame, double "Gunite" walls, single "Gunite" partitions, "Gunite" floor and roof slabs, and "Gunite" fire protection of columns and girders.

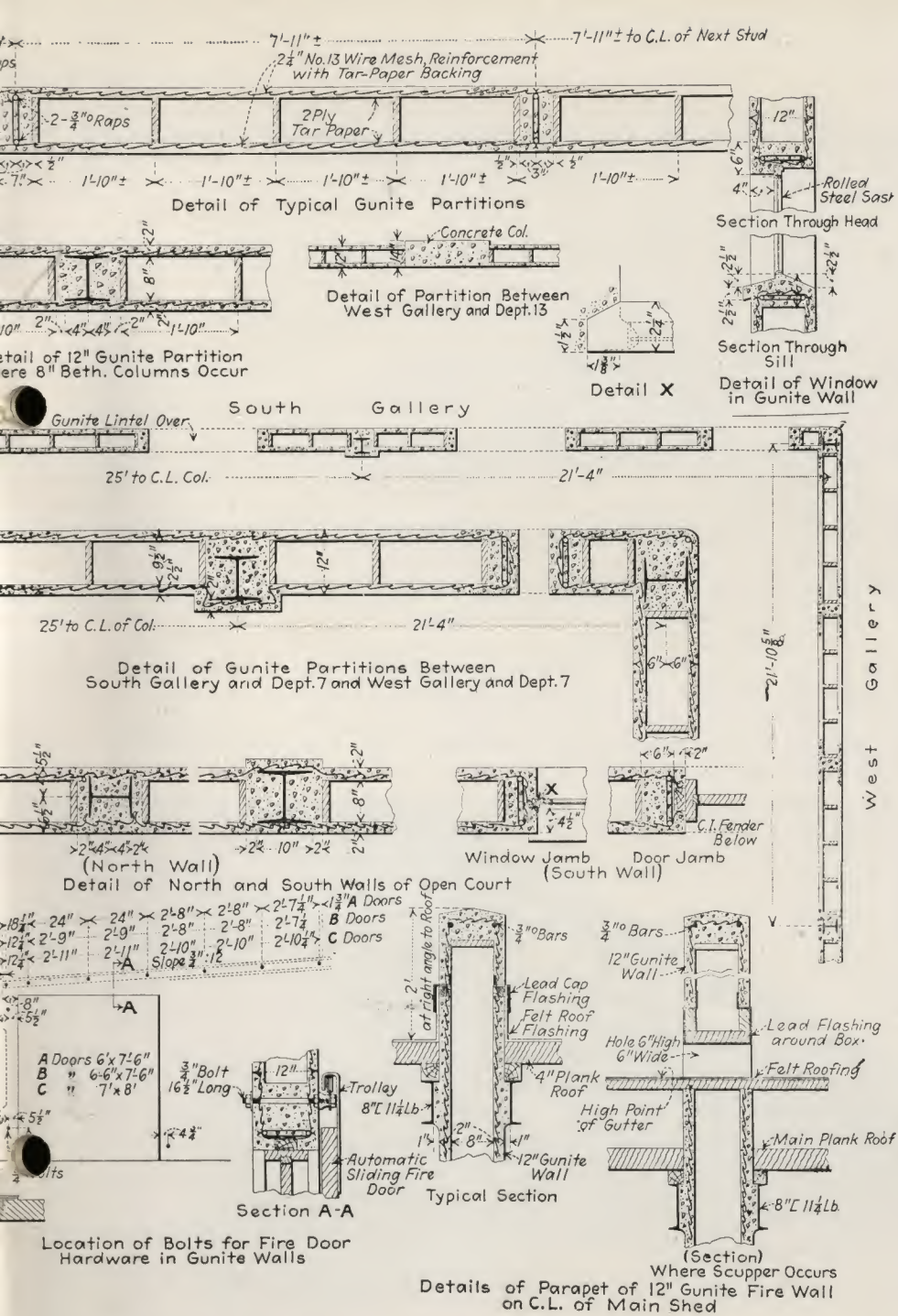


Figure 34. Details of building showing method of building interior forms for double walls; "Gunite" studs; "Gunite" column encasement; "Gunite" window jambs and sills. Note that the spacing between the "Gunite" studs is approximately 8 ft. centers.

Specifications were recently issued covering fire walls in a new Pier at Charleston, S. C., where a double "Gunite" wall of this type is provided for.

An estimate of the cost of a "Gunite" wall built in this way is hard to determine, due to the different prevailing conditions, but it is safe to assume practically the following for a building 60 or 70 feet high.

Forms (assuming one set used 5 times)	.020 per sq. ft.
Placing and removing forms	.050 per sq. ft.
Building and removing scaffold (labor and material)	.040 per sq. ft.
Reinforcing Mesh	.040 per sq. ft.
Placing mesh	.030 per sq. ft.
"Gunite" slab, 2" thick	
Materials: 1 bag cement $ .75	
3 cu. ft. sand .25	
Will cover 10 sq. ft. $1.00	.100 per sq. ft.
Labor—(Crew as shown on page 12), $48.50 per day will cover an average of 700 sq. ft. (this figure is conservative and is based on the average of a number of buildings)	.069 per sq. ft.
Power, plant depreciation, and renewals, $30.00 per day	.043 per sq. ft.
Cleaning up	.010 per sq. ft.
Total cost, exclusive of supervision, overhead and profit	**.402 cents per sq. ft.**

NOTE:—*The above costs are based on standard "Gunite" stipled finish. For floating, or other surface finish, additions must be made.*

It has not been found necessary in the walls of industrial buildings to provide expansion joints. As a matter of fact, the great freedom from cracking is very remarkable.

Figure 35. Quartermasters Department Warehouse at Norfolk, Va. Note spacing of posts 10' centers with "Gunite" slabs 2" thick between the posts. Buildings erected 1918.

Figure 36. Ford Motor Co. building at Iron Mountain, Mich. 2" "Gunite" Walls.
(Work done by our Contract Department)

In addition to the photographs shown here excellent illustrations of industrial buildings with "Gunite" walls are: the foundry buildings of Ingersoll-Rand Company, Painted, Post, N. Y.; several buildings of the River Rouge plant of the Ford Motor Company; the machine shop of the Seaboard Air Line at Portsmouth, Va.; the buildings of the plant of the Anaconda Copper Mining Co., Conda, Idaho; the buildings of the Peerless Portland Cement Co., Detroit, Mich.; Phoenix Portland Cement Co., Birmingham, Ala.; Lehigh Portland Cement Company, Bath, Pa.; The International Paper Co., Three Rivers and Gatineau, Canada; the Oval Wood Dish Company, Tupper Lake, N. Y., and the pier sheds of Port of Tacoma, Washington.

NOTE:—*Most of the illustrations given here are of buildings erected in latitudes where subjected to very cold temperatures.*

ROOF CONSTRUCTION

Construction of roofs is a very general use of "Gunite". In roof construction where no covering has been used over the "Gunite" it has been frequently customary to build the roofs without expansion joints, but our Company does not feel that this is the best practice, owing to the tendency of the frame of the building to move under unequal wind stresses. We, therefore, recommend that a distinct joint be placed along the center line of the trusses (at about 30 feet centers.) Over this joint an apron of reinforced "Gunite" can be shot, which will prevent leakage and will allow freedom of movement of the slab. We suggest a continuous mesh reinforcement of sufficient strength to resist the bending strain and with cross wires of sufficient area to resist temperature or "weave" stresses. **We recommend the use of welded fabrics or expanded metal and a mixture of 1 cement to 3 sand.**

There are numerous examples of "Gunite" roofs several years old which have never had any composition covering on them and are remarkably free from leaks. A notable example of this is the roof of the building in which the office of our Company is located. This is a wooden truss frame building with "Gunite" roof 2 inches thick, built in 1916, on which the maintenance charges to date have been less than $10.00.

In addition to the density of "Gunite" a probable cause of this success is the similarity in the coefficient of expansion of "Gunite" and steel. (See Page 32.)

Additional to the strength, water resisting qualities, and light weight of a "Gunite" roof, is the further advantage of absolute fireproofness. Tests made at Columbia University, as referred to in a report issued by the Underwriters' Laboratories, May 1922, showed that a slab one and one half inches thick, 6′ 3″ span, loaded with 40 lbs. per sq. ft. was subjected to a temperature of 1700° F., for three hours. Subsequently this slab when cooled was loaded with 200 lbs. per sq. ft. without failure.

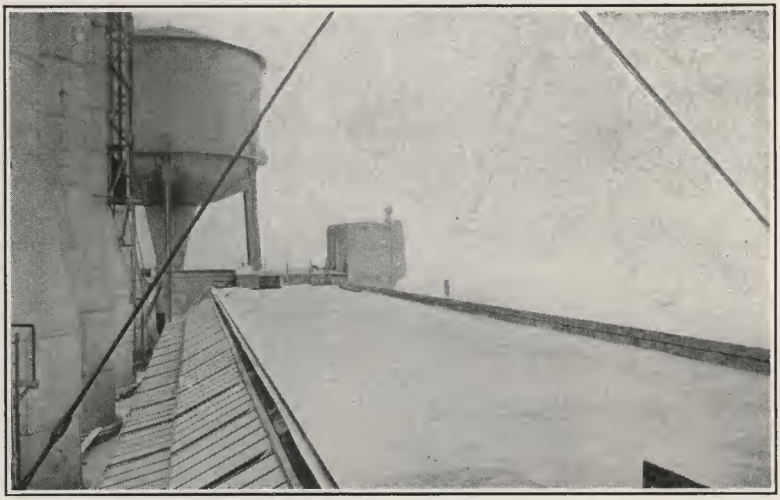


Figure 37. Roof of monitor over Power House, Ford Motor Co., Detroit. Built in 1915.

This roof has never had any roof covering over it and a recent statement from one of the engineers of the Ford Motor Co., is to the effect that:- *"The roof is still without covering, and no repairs have been made within the past five years."*

One of the large paper companies after several years of experimenting has adopted "Gunite" roofs as standard. They use slabs 2¼" thick on 8 ft. span, without covering, for a dry room; and the same type of slabs covered with 1½" of cork and standard roofing over their machine rooms where live steam is present. They have built several hundred thousand square feet of such roof within the last few years.

Figure 38. Building "Gunite" roof on pier shed at the Army Base, Norfolk, Va.

An interesting method of roof construction was adopted for the power house of the new plant of the Shawinigan Power Co., at LaGabelle, Que., where preshot slabs were used. They were cured in advance and placed by the derricks erecting the steel frame work.

The first authoritative tests regarding the strength of "Gunite" was made by the United States Shipping Board, the breaking tests being made by the Bureau of Standards. The average compressive value of the samples tested was in excess of 5,000 pounds per square inch. On the basis of these tests and on the basis of slab tests carried on by Lehigh University the tables shown on pages 34 and 35 were prepared.

The Building Department in the City of Seattle, Wash., in 1923, made tests to show the strength of 2 inch roof slabs, resulting in their approval of such construction, and similar tests made by other authorities have further confirmed the slab values shown in the tables and further described in our Bulletin on "Gunite" Slabs.

Tests were also made by the engineers of the New York and New Jersey Tunnel Commission in 1924 resulting in their specifying about 400,000 square feet of "Gunite" for the construction of the air ducts in

the four ventilation buildings of the Holland Tunnel. These tests are illustrated in Figs. 39 and 40.

Fig. 39. Showing test on "Gunite" slab by N. Y. and N. J. Tunnel Commission.

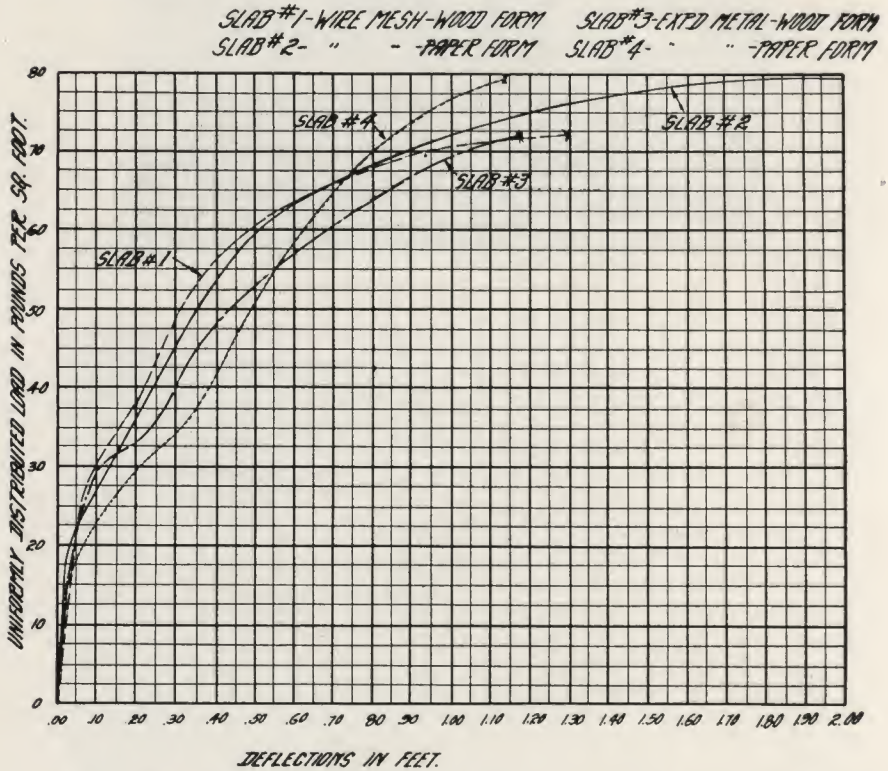


Fig. 40. Curve showing results of tests made by N. Y. and N. J. Tunnel Commission.

The most recent tests were those made by the California Institute of Technology in September, 1927, on "Gunite" samples (one part cement to four and one-half parts sand) taken from the ends of beams which showed an average strength of 5,050 pounds per square inch.

DOUBLE WALL CONSTRUCTION

The herein referred to report of the Underwriters' Laboratories also described a fire test made on a double "Gunite" wall consisting of two 2" slabs with 8" air space, and with "Gunite" studs spaced approximately 7' apart, (see cut page 21). One sample was subjected to a temperature ranging from 900° F. at five minutes to about 2100° F. at 257 minutes. A second test was made on a sample subjected to 1700° F. at one hour after which water at 50 lbs. pressure was shot against the heated surface for five minutes. Subsequent tests were made to show the stability of this type of wall against breaking down from the impact of falling beams. All of these tests were so successful that the wall has been described as being "better than a 12" brick wall."

These tests have led to the development of a most economical and efficient method of building exterior and fire walls, even for buildings of the highest type of fire resistance. The first use to any extent was for the exterior walls of a building at Broad St., and Lehigh Ave., Philadelphia. This building was described in AMERICAN ARCHITECT of July 4, 1923, and the statement was made that "the cost of these walls was 70% of the cost of adjacent plain brick walls 13" thick." The general construction of these walls was in accordance with the details shown on page 21.

Prior to adopting this form of construction the plans were submitted to and accepted by the Building Department of Philadelphia, as well as the Underwriters and the Factory Mutual Insurance Companies. The following letter is indicative of the feeling the Insurance Authorities have toward "Gunite".

NEW YORK FIRE INSURANCE RATING ORGANIZATION
95 MAIDEN LANE
FIFTH FLOOR

GOVERNING COMMITTEE

C. G. SMITH, CHAIRMAN — O. E. LANE
C. A. LUDLUM, VICE-CHAIRMAN — EDWARD MILLIGAN
J. A. SWINNERTON — WHITNEY PALACHE
JAMES MARSHALL — A. G. MARTIN
JAMES WYPER — ROBERT A. BARBOUR
LYMAN CANDEE — CHAS. M. KERR
C. S. CONKLIN — F. D. LAYTON
C. WESTON BAILEY

Address all communications to
BUMNER RHOADES, SECRETARY

NEW YORK. May 12, 1925

B. C. Collier, Esq., President
Cement Gun Company, Inc.
Allentown, Pennsylvania

Dear Mr. Collier:

I am very glad to forward you the following minute from the meeting of the Rating Managers of this State:

"Mr. B.C.Collier, President of the Cement Gun Company, Inc. of Allentown, Pennsylvania, presented various tests and information to the Managers. After Mr. Collier left, it was voted t notify the Cement Gun Company that the Organization is favorably disposed toward passing Gunite for exterior panel walls (two inches material, void and two inches material) for skeleton frame fire-resistive buildings without penalty in the Syracuse, Buffalo and Suburban Divisions.

"The Organization asked that the Division having jurisdiction be notified of jobs of any size in order that same may be inspected while under construction.

"The Organization will also be glad to take up with the Cement Gun Company at any time specific cases where it is proposed to use Gunite for interior stair and elevator shaft walls or partition walls."

From the last paragraph of the above you will see that we are willing to go into the study of this type of construction further.

With best regards, I am

Very truly yours,

SR*B — Secretary.

The Washington State Rating Bureau gave the Port of Tacoma, for a pier built with wooden piles covered with "Gunite", wooden trusses, and two inch "Gunite" walls, a rating of $0.31 per $100.00.

"GUNITE" FLOOR SLABS

Due to its adhesion to concrete "Gunite" is extensively used for the restoration of destroyed concrete floor surfaces, and also for original construction of floors. By its use a topping can be placed at any time subsequent to the pouring of the concrete and a perfect monolithic condition obtained. Tests have also been made which show much higher resistance to abrasion than can be obtained by the use of concrete with liquid hardeners.

In 1919 repairs were made on concrete floors at the plant of the Sefton Mfg. Corp., which had, due to the heavy service of steel shod trucks, become badly broken up and corroded. The results of these repairs, which were made with reinforcment, are shown in the following letter.

SEFTON MANUFACTURING CORPORATION

CORRUGATED FIBRE BOARD
FOLDING BOXES, PAPER PAILS

FACTORIES
CHICAGO-BROOKLYN
ANDERSON, IND.
GENERAL OFFICES CHICAGO

TELEPHONE MAIN 427

ANDERSON, IND.

PLEASE ADDRESS REPLY
DIRECT TO
ANDERSON OFFICE

Jan. 26,
1 9 2 8.

Cement-Gun Company, Inc.,
Allentown,
Pa.

Gentlemen: Attention Mr. B.C.Collier,
President.

The Cement-Gun work done on some floors and ceilings in this plant during the summer of 1919 is still standing up in wonderful shape.

An eminent Chicago Engineer who inspected our floors this last summer pronounced the cement-gun floor as being perfectly sound in every particular.

Yours very truly,

SEFTON MANUFACTURING CORPORATION

(John Hyde)
Superintendent.

JH/m

In 1925 our Contract Department restored School No. 68, Buffalo, N. Y., a new structure which had been condemned due to defective concrete. In this restoration it was necessary to remove and replace most of the floors. Fig. 41 shows these restored floors. A test was applied to them by loading with 250 tons of pig iron, (equivalent to 199 pounds per square foot, or four times the designed load), under which loading the deflection was less than calculated for the designed load.

Figure 41. View in School Number 68, Buffalo, N. Y., showing the refinished class-room floors and the old concrete top removed from the corridor floors to receive the "Gunite".
(Work done by our Contract Department)

STEEL ENCASEMENT

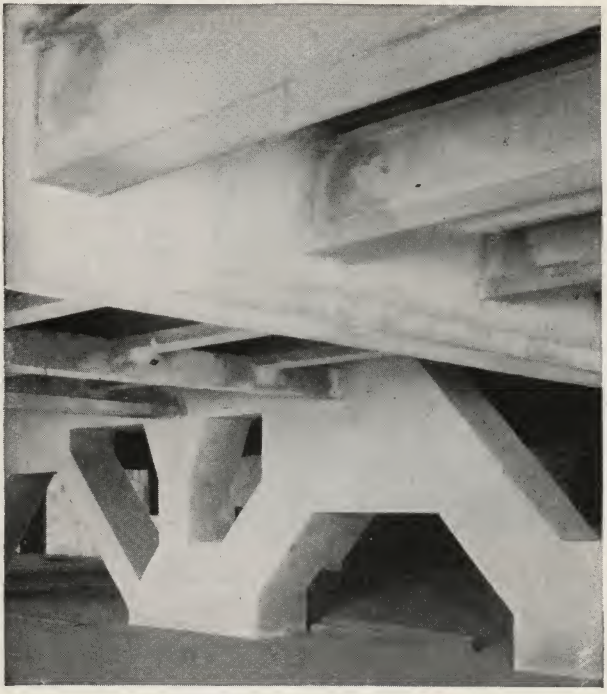
In addition to its fireproofing qualities "Gunite" has long been recognized as the most effective method yet developed for protecting steel against corrosion. This is proven by the fact that in practically all steel bridges and viaducts now being built "Gunite" is being specified as the method of protecting all steel exposed to severe conditions. A very extended test of this was carried on by the University of Toronto and reported in their Bulletin No. 4—1924. In this report the statement is made that:

"*Neat Portland Cement is known to be an effective preventive of rusting when applied to steel surfaces and on occasions has been employed as a paint for this purpose. To afford a satisfactory protection for steel reinforcement it is advisable that the metal be surrounded by a mortar rich in cement applied preferably wet, as this insures that all parts be coated. Gunite is a concrete essentially of this character, but since it is applied under pressure it possesses greater density than ordinary concrete. When the raw materials are forced under pressure against a hard metal surface there is considerable rebound—mostly of the sand. This means that the cement adheres to the surface as a matrix into which the particles of sand are subsequently driven. This matrix is a preventative of corrosion.*"

An article in THE AMERICAN ARCHITECT of June 3, 1925, describes the work done in fireproofing the steel in the Bronx Terminal Market, New York City, and figures are brought out to show the great saving in dead load on the structure by the use of the "Gunite" encase-

ment over what would have been the loading with the usual standard method of concrete haunch encasement. The statement is made that:—

"The economical advantages due to the use of this method in constructing the Bronx Terminal Market can be summed up as follows:—Decrease in the dead load of beam encasement resulting in a lighter structural steel floor system; lighter column sections and smaller foundations; decrease in the cost of the beam encasement and rapidity of construction."



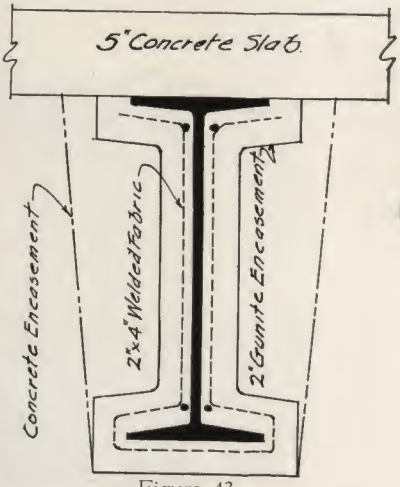


Figure 43.
Detail showing the relative area of cross section between the ordinary concrete encasement and "Gunite" encasement.

← Fig. 42. Finished "Gunite" encasement of beams, girders and trusses, Bronx Terminal Market, N. Y. C.
(Work done by our Contract Department)

Tests made recently at Ohio State University (Bulletin 37, 1928) indicate that conservative practice will allow the elimination of dead load penalties on beams and girders occassioned by "Gunite" encasement. This further reduces the weight of the various members in the structnre. Note curve shown in Fig. 44.

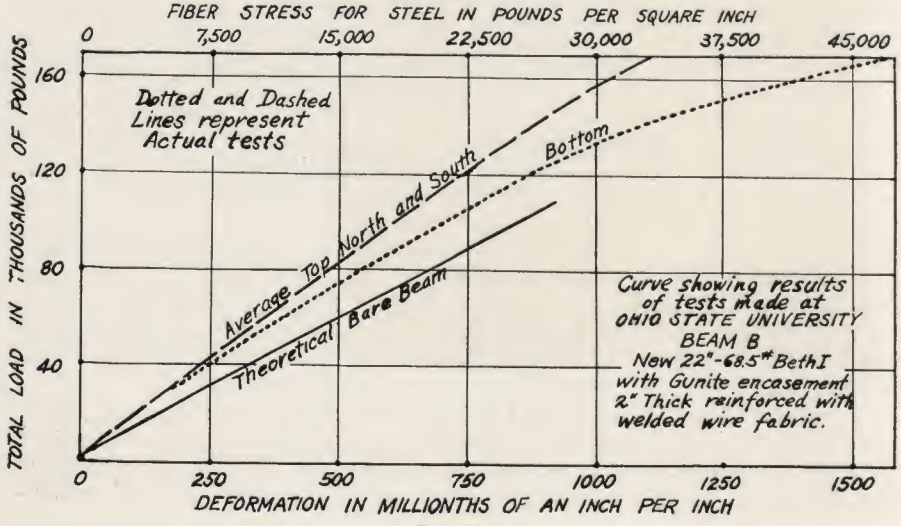


Fig. 44.

Fig. 45. "Gunite" steel encasement, Lehigh Valley R. R. Station, Easton, Pa.

The first use of the "Cement-Gun" in steel encasement was at Grand Central Station, New York, where over five million square feet of "Gunite" have been placed as a protection against fire and corrosion.

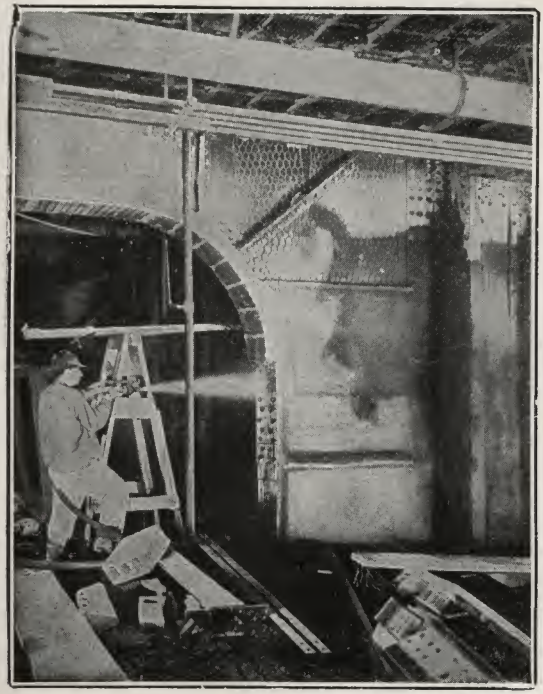


Figure 46. Protecting steel with "Gunite." Woolworth Bldg., N. Y. C.

It will also be of interest to know that "Gunite" is specified for the protection of practically all of the steel in the viaduct approaches to the Holland Tunnel in Jersey City. Contracts for over one million square feet have been let at this writing.

One of the most extended uses of "Gunite" is in the restoration and strengthening of concrete and steel buildings regarding which we have additional bulletins. If you desire this information please write for same.

STADIUMS

The values of "Gunite" for roof or floor slabs in addition to the further advantages obtained by its protection of steel has resulted in the development of a type of stadium construction which has proven to be not only economical and permanent, but offers the further advantage of rapidity of construction.

A very striking illustration of the use of a steel frame and "Gunite" treads and risers in stadium construction is that of the stadium built for the Nash Motor Company at Kenosha, Wis. during the winter of 1920 and 1921. The specifications called for a prompt fulfillment of a short term contract and although under severe winter conditions, the work was completed on time. The seating capacity is 2,700 people at a contract price of $30,000.00, or $11.00 per seat, for this covered stadium. It is reported to us from a recent examination that there is no evidence of any cracking or deterioration.

The illustration shown on Page 14 is a very excellent example of the architectural effects that can be developed and obtained for the walls of such structures.

Coefficient of Expansion Tests on "Gunite" as determined by Professor M. O. Fuller, Lehigh University in report dated January 4, 1924.

Spec. No.	Original length in inches	Room Temp. F	Highest Temp. Rec'd F	Diff. in Temp.	Mean of Two Telescope Readings Inch	Coef. Exp. per Degree F
1	6.05	57	1098	1041	.04120	.00000654
2	5.53	60	970	910	.03220	.00000644
3	5.32	60	1234	1174	.04020	.00000643
4	6.03	60	1198	1138	.04390	.00000641
5	5.83	60	1297	1237	.04637	.00000643

For full details of these tests see 1924 proceedings American Concrete Institute. (See Reference Page 124.)

THE UNIFORM BUILDING CODE

Adopted February 1928

by

THE PACIFIC COAST BUILDING OFFICIALS CONFERENCE

Gives to "GUNITE" the following values

As protection for steel members

	Columns and Girder flanges	Beams, and Webs of Girders
4 hr. resistance	2½" thick	2" thick
3 " "	1½" "	1" "
2 " "	1 " "	¾" "
1 " "	¾" "	¾" "

As thicknesses for walls

4 hr. Resistance	Reinforced "Gunite" 5" thick, or double wall 10" thick with outer slabs 2" thick.
3 " "	Reinforced "Gunite" 3½" thick, or double wall 8" thick with outer slabs 1½" thick.
2 " "	Reinforced "Gunite" 2½" thick.
1 " "	" " 1½" "

Each of these allowances is about 20% better than that made for any other type of construction

Fig. 47. Showing condition of concrete in chocolate factory in Berlin, after fire.

Fig. 48. Showing "Gunite" repairs being made and increase in size of members in chocolate factory.

(See article in AMERICAN ARCHITECT, Nov. 8, 1922)

Fig. 49. Cut showing how the girders and beams in a concrete building in Phoenix, Ariz. were strengthened and rebuilt with "Gunite" to change the live load capacity from 60 pounds per square foot to 200 pounds per square foot.

An article in AMERICAN ARCHITECT, Oct. 20, 1925 describes this and also describes how steel buildings are similarly strengthened.

No 4

SAFE LIVE LOADS FOR GUNITE SLABS

NON-CONTINUOUS MESH REINFORCEMENT

GUNITE AT 1500 LBS. SQ. IN
STEEL AT 16000 LBS. SQ. IN

1:3 MIX FACTOR OF SAFTY = 4

TOTAL THICKNESS OF SLAB IS GIVEN IN LARGE BLOCK NUMERALS UNDER GIVEN SPAN AND OPPOSITE DESIRED LIVE LOAD, FIND THE AREA OF REINFORCEMENT REQUIRED PER FOOT OF WIDTH OF SLAB.

FOR SLABS 2½ INCHES OR LESS IN THICKNESS, ONE HALF (½) INCH IS ALLOWED FROM BOTTOM OF SLAB TO CENTER OF STEEL FOR PROTECTION, AND THREE-QUARTER (¾) INCHES FOR SLABS GREATER THAN 2½ INCHES IN THICKNESS.

IT IS RECOMMENDED THAT A TOTAL THICKNESS OF TWO (2) INCHES BE EMPLOYED AS A MINIMUM FOR FLOOR SLABS AND ONE AND ONE-HALF (1½) INCHES FOR ROOF SLABS

SPAN / Lbs PER SQ. FT.	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"
30	.045	060	.080	.100	.124	.155	.185	.220	.215	.250	.290
40	.055	.075	.095	.125	.155	192	220	.225	.260	.305	.240
50	.060	085	.115	.150	.185	.230	.225	.260	305	.300	.330
60	.075	.100	.135	.170	.215	.265	.253	.300	.300	.350	.400
70	.085	.115	.150	.195	.245	.240	.290	290	.340	.325	.390
80	.090	.130	.170	.220	.220	.270	.330	.320	.375	.380	.435
90	.100	.140	.190	.240	.245	.300	.300	.355	.360	.415	.420
100	.110	.155	.210	.265	.280	.325	.340	.390	.390	.465	.460
110	.120	.165	225	.230	.290	.295	355	.365	.425	.435	.500
120	.135	.185	.245	.250	.315	.320	.385	.390	.405	.465	.535
130	.145	.200	.265	.270	.335	345	.350	.420	.430	.500	.520
140	.155	.215	.225	.290	.300	.370	.380	.445	.460	.535	.555
150	.165	.230	.240	.305	.320	.390	.405	.480	485	.510	.590
160	.175	.240	.255	.325	.340	.350	.425	.445	.520	.545	.645
170	.185	.255	.270	.285	.360	.372	.450	.465	.495	520	.595
180	.194	.270	.285	.300	.380	.400	.480	.495	.520	.605	.620
190	.205	.235	.300	315	.400	.415	.435	.520	.545	.570	.655
200	.215	.235	.315	.335	.355	.435	460	.545	.570	.600	.690

1½ 2 2½ 1¾ 2¼ 3 3¼

NOTE:— FOR TOTAL LOAD ON STRUCTURAL FRAME WORK ADD WEIGHT OF SLAB TO LIVE LOAD, AT 12 LBS. FOR EACH INCH THICKNESS.
TO OBTAIN TOTAL SAFE LOAD FOR CONTINUOUS MESH REINFORCEMENT ADD 50 PER. CENT.

Aug 7, 1920

M. J. Fuller
LEHIGH UNIVERSITY

Geo E. Strehan, Cons Engr.
112 West 42 St. N.Y.C

No 1

SAFE LIVE LOADS FOR GUNITE SLABS

NON-CONTINUOUS MESH REINFORCEMENT

GUNITE AT 1500 LBS. Sq. IN. STEEL AT 20000 LBS. Sq. IN. 1:3 MIX FACTOR OF SAFTY = 4

TOTAL THICKNESS OF SLAB IS GIVEN IN LARGE BLOCK NUMERALS. UNDER GIVEN SPAN AND OPPOSITE DESIRED LIVE LOAD, FIND THE AREA OF REINFORCEMENT REQUIRED PER FOOT OF WIDTH OF SLAB.

FOR SLABS 2½ INCHES OR LESS IN THICKNESS, ONE HALF (½) INCH IS ALLOWED FROM BOTTOM OF SLAB TO CENTER OF STEEL FOR PROTECTION, AND THREE-QUARTER (¾) INCHES FOR SLABS GREATER THAN 2½ INCHES IN THICKNESS.

IT IS RECOMMENDED THAT A TOTAL THICKNESS OF TWO (2) INCHES BE EMPLOYED AS A MINIMUM FOR FLOOR SLABS AND ONE AND ONE HALF (1½) INCHES FOR ROOF SLABS

SPAN IN FT. / LIVE LOAD	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"
30	.035	.050	.065	.080	.100	.125	.145	.145	.17	.200	.200
40	.040	.060	.080	.100	.120	.150	.150	.185	.205	.205	.225
50	.055	.075	.090	.120	.145	.180	.18	.215	.205	.240	.275
60	.060	.080	.110	.135	.170	.170	.225	.225	.240	.275	.275
70	.065	.090	.120	.155	.155	.190	.190	.225	.270	.270	.310
80	.075	.100	.135	.195	.170	.210	.215	.255	.260	.300	.300
90	.080	.115	1½ .150	.155	.190	.185	.235	.240	.285	.295	.335
100	.095	.120	.165	.170	.210	.215	2 .260	.260	.310	.330	.360
110	.095	.130	.180	.185	.190	.235	.240	.285	.295	.340	.360
120	.105	.135	.155	.200	.205	.250	2¼ .260	.310	.320	.370	.385
130	.115	.155	1¾ .165	.210	.220	.235	.280	.290	.340	.355	.405
140	.120	.170	.175	.225	.235	250	.260	.310	.360	.370	.440
150	.130	.180	.190	.200	.250	.260	.275	2½ .330	.350	3 .405	.420
160	.140	.190	.200	.220	.265	.280	.295	.350	.370	.430	.445
170	.145	.160	.215	.225	.240	.295	.310	.365	.390	.405	.465
180	.155	.170	.185	.240	.255	.275	.325	.350	.415	3¼ .430	.445
190	.125	.185	.195	.210	.270	.290	.345	.365	.385	.450	.470
200	.135	.190	.205	.220	.245	.300	.360	.385	.405	.430	3½ .490

NOTE:- FOR TOTAL LOAD ON STRUCTURAL FRAMEWORK ADD WEIGHT OF SLAB TO LIVE LOAD AT 12 LBS. FOR EACH INCH THICKNESS. TO OBTAIN TOTAL SAFE LOAD FOR CONTINUOUS MESH REINFORCEMENT, ADD 50 PER CENT.

M. J. Fuller (ENGINEER)

Geo. E. Stehan. CONS. ENGR. 112 West 42St. NYC

Aug. 7, 1920.

SOME DETAILS OF "GUNITE" CONSTRUCTION ALWAYS NECESSARY TO BEAR IN MIND

1st. Sufficient air must be provided: The N-00 machine requires a minimum of 60 cu. ft. of **actual** free air per minute at 35 to 50 pounds pressure. The N-0 machine requires a minimum of 100 cu. ft. of **actual** free air per minute at from 35 to 50 pounds pressure. The N-1 machine requires a minimum of 175 cu. ft. **actual** free air per minute at from 35 to 50 pounds pressure. The N-2 machine requires about 225 cu. ft. **actual** free air per minute at from 40 to 60 pounds pressure.

2nd. For successful operation with least loss of time the air should be thoroughly dried. We recommend the Traylor-Dewey Air Dryer for this purpose. With wet air there is always a tendency of the hose to become clogged due to the cement adhering to the walls of the hose. This adhesion causes stoppages which must be located and removed. As a prevention of such stoppages it is always wise to use the by-pass blow-off to clear the hose during any short periods when machine is not operating.

3rd. Successful operation of a "Cement-Gun" demands that the machine be cleaned out thoroughly each night, or when work stops. Otherwise the cement left in the machine will set up.

4th. In order to produce true surfaces the nozzleman must keep the stream of mortar continuously moving so that the "Gunite" is placed on the wall in thin layers, thereby avoiding lumpiness.

5th. The nozzle man should hold the nozzle at as near right angles to the surface being covered as possible, and the nozzle should be held at about 3 feet from the surface.

6th. The best results are obtained with from 50 to 150 feet of hose from the machine to the nozzle. Excellent results, both in character of "Gunite" and progress made, have been obtained with as much as 450 feet of hose, raising the material 80 feet. In this case air pressure of about 75 pounds at the machine was needed. "Gunite" has been elevated to as great a height as 250 feet, but in such cases it is advisable to use a "booster jet" of air.

7th. The "Cement-Gun" is frequently employed as a sand blast machine. In case of such use in cleaning steel the sand should be "bone-dry;" a special nozzle should be used; and the feed wheel should be operated very slowly. If the machine is run rapidly with dry sand static electricity is developed.

8th. In cleaning concrete or masonry surfaces the sand blasting is done with the smallest sized regular nozzle; with ordinary sand; and with the addition of water to the sand. Before applying the "Gunite" the surface must always be washed down with water and compressed air.

9th. **Remember the several instructions and specifications in this Bulletin regarding the type and method of placing reinforcing mesh, and with the above restrictions, and care and judgment on the part of the engineer, walls will be produced which have no equal in any other type of construction. The "Cement-Gun" is only a machine and needs your help.**

THE FOLLOWING SPECIFICATIONS ARE TAKEN FROM AMERICAN ARCHITECT SPECIFICATION MANUAL, 1923 EDITION

WITH CHANGES INCORPORATED BY CEMENT GUN COMPANY, INC. AFTER CONSULTATION WITH SEVERAL "CEMENT GUN" SPECIALISTS.

GENERAL SPECIFICATIONS FOR "GUNITE"

1. "Gunite" as used herein is the name given to a mixture of sand and cement of the proportions specified for different types of work, thoroughly mixed in a dry state, and placed under pneumatic pressure with a machine manufactured under the Trade Name and Trade Mark "Cement-Gun".

2. Cement shall be any brand of standard Portland Cement which shall conform to the specifications of the American Society of Testing Materials. Each bag of cement shall be deemed to be one cubic foot.

3. Sand shall be clean, sharp and reasonably free from clay, loam or silt. It shall be well graded and have sufficient fine material partially to fill the voids between the coarser particles.

4. The term "dry" as applied to the sand to be used shall not mean that all moisture must be removed but rather that it shall contain a normal content of not less than 3 per cent. of moisture.

5. Before placing the mixture in the hopper of the "Cement-Gun" all material and lumps over ⅜ inch in size shall be removed by screening.

6. No less pneumatic pressure than 30 pounds per square inch at the "Cement-Gun" shall be used in placing the mixed material. Where the lengths of hose exceed 100 feet the pressure at the "Gun" shall be increased so as to produce a minimum nozzle velocity equivalent to 30 pounds air pressure at the "Gun" with 100 feet of hose. Air must be maintained at a steady pressure.

7. The water used in hydrating the material at the nozzle shall be clean and free from all substances that would interfere with the setting qualities or strength of the cement. It shall be maintained at a uniform pressure of 60 pounds per square inch or at a pressure greater than 15 pounds above the pressure of the air used.

8. The contractor shall do the work only with experienced men. No man operating the nozzle of the "Cement-Gun" will be deemed experienced unless he has done considerable work on other contracts where the work was of a similar type to that specified, or has otherwise proved his qualifications to the satisfaction of the Architect (or Engineer)by other equally important work.

9. In shooting all surfaces the nozzle shall be held at such distance and position that the stream of flowing material shall impinge as nearly as possible at right angles to the surface being covered. Any deposit of loose sand shall be removed prior to placing any original or succeeding layers of "Gunite", and should any sand deposit be covered with "Gunite" it shall be cut out and replaced with "Gunite".

10. At end of day's work, or other similar stoppage points, the "Gunite" shall be sloped off to a thin edge. Before shooting the adjacent section, this sloped portion shall be thoroughly cleaned and wetted. No square joints will be allowed.

11. The "Gunite" shall be kept dampened for at least four days after placing. No "Gunite" shall be placed during freezing weather unless under direction and precautions directed by the Architect (or Engineer)and in no case shall it be placed against any surface (steel or masonry) on which any frost is present.

12. In case of "Gunite" construction where steel members are to be encased by, or to support "Gunite", they shall be delivered and erected unpainted.

FIREPROOFING OF STEEL COLUMNS, GIRDERS AND BEAMS

13. "Gunite shall" be mixed in the proportions of one part cement and three parts of sand.

14. The metal reinforcing mesh used shall be galvanized. It shall be either electric welded fabric of No. 12 wires spaced 2 inches in each direction, or No. 10 wires spaced 3 inches in each direction; or it may be expanded metal of no less then 2 inch opening and of equivalent cross sectional area and weight as the welded fabric. Holes not less than $\frac{5}{8}$ inch in diameter, for attaching the "Gunite" reinforcement shall be punched, during fabrication, in webs of members, as near as possible to top and bottom flanges. These holes shall be spaced on approximately 3 foot centers. Where steel members are more than 5 feet in depth an additional row of holes spaced on 3 foot centers shall be provided in center line of web. In placing the mesh, rods no less than $\frac{3}{8}$ inch in diameter shall first be fastened to the steel through holes punched in the webs or stiffeners, and subsequently the mesh shall be securely tied outside of these rods with wires spaced at about 12 inch intervals. The mesh shall conform, in so far as possible, to a spacing $\frac{1}{2}$ inch out from the face of the steel members. Wherever adjacent sheets meet they shall lap at least 4 inches and the sheets shall be securely and properly fastened together.

15. The steel members to be covered with "Gunite" shall be cleaned thoroughly of paint; rust-scale; grease or other material before the "Gunite" is applied.

16. The "Gunite" encasement for all steel columns or girders shall follow generally the outline of the members, and shall have, except as especially provided, a thickness of 2 inches. The encasement for floor beams between girders shall have a thickness of $1\frac{1}{2}$ inches. If called for, the corners shall be squared and the surface of the "Gunite" shall be finished as directed.

17. For all exposed members, "shooting strips" shall be employed to insure square corners and proper thicknesses of the "Gunite". The finish of the web portion of the "Gunite" shall, when exposed to view, be treated with a "brush coat" of clean water applied with a whitewash brush, or with a "flash coat" finish.

18. Measurement of all areas shall be deemed to be actual area of the "Gunite" encasement of the members to be covered measured along the center line of the "Gunite" section, and payment, per square foot of "Gunite", shall be made on such basis.

FLOOR AND ROOF SLABS

19. "Gunite" for floor and roof slabs shall consist of one part cement and three parts sand.

20. The reinforcing mesh for the slabs shall be galvanized. It shall be of welded wire fabric or expanded metal of equivalent weight

and area as may be called for on the drawings. The sheets shall be of sufficient size, and so laid that they may, wherever possible, form a continuous reinforcement past at least one supporting beam. Adjacent sheets shall have a side and end lap of one mesh. Sheets shall be tied together at about 18 inch intervals and they shall be held in correct position, in no case approaching nearer than ¾ inch to any exposed surface.

21. When a slab is continuous over a support, additional reinforcing mesh shall be provided near the upper surface of the slab for one-fifth of the span on each side of the support.

22. Forms for "Gunite" slabs shall be made of well built wooden panels or steel plates, or other approved methods. They shall be held in place in such manner as to insure against sagging or dropping from the imposed weight. Forms shall remain in place at least 48 hours after shooting.

23. The slabs may be shot in two or more layers as may be demanded for the thickness required. The final coat will be shot to a thickness of approximately ½ inch against the previously rodded, straightened and thoroughly cleaned and wetted surface, and shall be finished by "brush coating" with a whitewash brush and clean water, by floating, or by troweling, as may be specified and shown on the drawings.

"GUNITE" WALLS FOR INDUSTRIAL BUILDINGS

24. "Gunite" for walls shall be mixed in the proportions of one part cement to four parts sand and shall be applied to such thickness as shown on the drawings. They shall be not less than 1½ inches thick for spans up to 4 feet, and 2 inches thick for spans up to 7 feet.

25. The walls shall be reinforced either with galvanized welded wire fabric with wires spaced not more than 3 inches apart in each direction, or with galvanized expanded metal with openings not more than 2¼ inches by 6 inches. The cross sectional area per foot of mesh in each direction shall be not less than four-tenths of one per cent of the cross sectional area per foot of wall.

26. In case the framework of the building is of structural steel, holes 7/16 inch in diameter on 18 inch centers shall be provided by the structural steel contractor in all members intended to support the "Gunite" wall. To these members rods ¼ inch in diameter shall be securely fastened by ¼ inch bolts spaced 18 inches on centers. These rods shall be furred out from the structural steel members not less than ½ inch. To these rods the reinforcing mesh shall be wired by No. 14 gauge, black, annealed wire at intervals of 12 inches.

If the framework of the building is of concrete, No. 10 gauge annealed wire loops shall be placed through the forms every 18 inches along the beam, girder, or column before the concrete is poured. The reinforcing mesh shall be fastened by twisting the ends of these loops about the mesh, care being taken to furr the mesh at least ¾ inch from the concrete surface.

27. Permanent or temporary backing of tarred felt (weighing no less than 30 pounds to each 100 sq. ft.), or of metal or wooden panels, shall be placed in such manner that the completed wall will be of the thickness shown on the plans over each point of support.

28. Reinforcing mesh shall be carefully bent to template prior to placing around corners, or in re-entrant angles. In no case will the contractor be allowed to "spring" the mesh into place. Lapping shall be at least the width of one mesh in each direction. All laps shall be firmly tied together at intervals not exceeding 18 inches. When a joint comes at the corner, an extra sheet of mesh 18 inches wide shall be bent around the corner and securely fastened to the other sheets.

29. At the corner of all door, window or other openings a strip of mesh at least 9 inches by 24 inches shall be placed diagonally across the corner of the opening. This strip shall be wired to the sheets.

30. The mesh shall be fastened to all door bucks or window frames, and, where shown on the plans, at each outside exposed window or door-frame an approved water stop of copper strip or galvanized iron will be placed and fastened to the mesh and to the frame.

31. Over this mesh and backing, the "Gunite" shall be shot in one or more coats to approximately within ¼ inch of the finished surface of the completed wall. The surface of this coat shall, when fresh, be rodded to true lines by using a flat, steel edged screed, or by a trowel or other sharp cutting edge. In no case shall the "Gunite" be 'dragged' as is usually done with hand placed cement plaster. The final coat shall be shot in place and finished as specified in Clause 37. Before placing the finishing coat the surface of the preceding coat shall be thoroughly wetted and washed down with compressed air and water.

32. Shooting, or guide strips, shall be placed around all openings and corners, or around all panels or cornices, or other effect, not only to insure proper thickness but also to secure true lines and corners.

33. Where double walls are shown on the drawings the two slabs shall be connected at intervals with solid studs shot monolithically with the slabs. The studs shall be spaced as indicated on the drawings and they shall be reinforced with vertical rods as shown. To these rods, which have been firmly tied together through the stud space, the reinforcing mesh shall be fastened. The forms for this double wall construction will be left in place inside the wall.

"GUNITE" COVERING FOR BRICK OR TILE WALLS – WATERPROOFING

34. "Gunite" shall be composed of one part of cement to three parts of sand.

35. Prior to applying the "Gunite" the surface shall be thoroughly cleaned and shall be washed down with water and compressed air.

36. Over the cleaned and wetted surface the "Gunite "shall be shot to a thickness of no less than ½ inch. The first coat shall then be carefully rodded with a sharp, steel edged screed or trowel and subsequently the final coat shall be applied. Before applying the flash coat the previous surface must be washed down and thoroughly wetted.

37. The finish coat will be treated with a "brush coat", or by troweling or by such treatment as may be called for on the drawings. When called for, a brush treatment of colored cement stucco shall be applied over the completed surface.

38. Where the existing walls show leaking or disintegrated conditions, prior to shooting the "Gunite", and subsequent to cleaning the surface, a layer of galvanized welded fabric, or galvanized expanded metal, with openings about 2 inches across will be fastened to the wall by means of expansion bolts, or by other suitable method. The "Gunite" then shall be applied in two or more layers to such thickness as shown on the plans, but in no case to a thickness of less than one inch.

39. In case excessive water conditions prevent the proper setting of the "Gunite", the contractor shall arrange to lead the water away from the surface against which the "Gunite" is being shot by weep pipes or other suitable and satisfactory method. These weep pipes will be subsequently capped and protected by the contractor.

"GUNITE"

The Sand and Cement Product of the Machine Manufactured Exclusively by the

CEMENT GUN CO., Inc.

Allentown, Penna., U.S.A.

under the Trade Name and Trade Mark "Cement Gun"

in

Repairing, Maintaining and Constructing
Masonry Structures, Sewers, Dams, Tunnels, Reservoirs
and Irrigation Ditches

Old stone arch at Eaton, Preble County, Ohio, before and after being restored by "GUNITE" by our Contract Department.

"GUNITE", as described by the Portland Cement Association and referred to by numerous Government, State and Municipal specifications, is:

"The trade name given to a mixture of sand and cement applied by pneumatic pressure with a machine manufactured under the trade name "CEMENT-GUN".

"GUNITE" possesses several characteristics that make it particularly adaptable for the repairs, protection and preservation of new and old concrete or masonry structures. These characteristics are—

1st. ADHESION.

Numerous experiments and actual illustrations in practical work have shown that the adhesion between "GUNITE" and the material to which it is applied is stronger than the material itself. One of the most positive proofs of this was shown by tests made at the University of California to determine this working strength, in order to design "GUNITE" collars to be shot around columns for supporting a building to be underpinned, The "jacking" was done against beams under these collars. These tests developed a shear value of 600 lbs. per square inch in the concrete, and as the bond between the "GUNITE" and the concrete was not broken, the adhesion was manifestly greater than this.

Tests were also made to determine this bond by the U. S. Shipping Board, Concrete Ship Division, and as a result "GUNITE" was used to protect the surface of the concrete ships against the destructive action of salt water.

A very practical illustration of positive bond is that of a brick wall of a paper manufacturing building in Canada. During 1925, this wall, which was subject to very severe damp conditions from the inside, was covered with about one inch of unreinforced "GUNITE". During the spring of 1929 a large area (approximately 1000 square feet) of this "GUNITE" coating fell away, and in falling pulled from one-quarter to one-half inch of the entire brick surface with it. Had the wall been properly protected from the inside no such hazards would have existed.

To insure this positive adhesion the surface must be thoroughly cleaned of all laitance, scum or any other film, and wetted before the "GUNITE" is applied.

2nd. DENSITY.

The density of "GUNITE" is due to the method of application, since the material is transported in a relatively dry state to the nozzle where water is added just as it is propelled at high velocity against the surface to be protected.

This density is proven not only by numerous tests of reservoirs and other similar structures lined with "GUNITE" either over the old surface or directly against the earth, but especially by such tests as were made by the University of California and reported in the Transactions of American Society of Civil Engineers, page 906 of 1917 issue. The statement is made that—

"Several plaster slabs, from 5/8 to 1½ in. thick, made at Gem Lake, were tested with water pressures ranging from 700 to 1600 ft., for several hours, with no moisture coming through the slab. One 1-in. slab held a head of 1610 ft. for 2½ hours without showing moisture, then the water pressure was raised gradually to 3400 ft., and the specimen broke in bending, having leaked a little before breaking".

3rd. STRENGTH.

The method of placing "GUNITE" results in the production of a material with a proven ultimate compressive strength averaging between 4500 and 8000 lbs. per square inch. The following tests show these values:

RESULTS OF MISCELLANEOUS TESTS TAKEN FROM SERIES MADE BY EMERGENCY FLEET CORPORATION (1918) AND TESTED BY BUREAU OF STANDARDS WASHINGTON.

SHOOTING POSITION	NUMBER OF LAYERS OF GUNITE	SHOOTING INTERVALS - HOURS.	AGGREGATE SIZE - PROPORTIONS. THRU #8	THRU #8 ON #8	THRU #4 ON #6	SAND CEMENT PROPORTIONS CEMENT	SAND	REINFORCING SCREEN ROUND RODS DIAMETER	SPACING.	COMPRESSION AT 90 DAYS OR MORE PERPENDICULAR	PARALLEL	REMARKS
V	6	24	1/2	1/4	1/4	1	3.75	⌐	⌐	5236	5015	THIS SET MARKED "SOAKED BEFORE SHOOTING."
										5319	5080	
										5330	4256	
V	6	24	1/2	1/4	1/4	1	3.75	⌐	⌐	5333	4522	THIS SET MARKED "SOAKED AND SAND BLASTED BEFORE SHOOTING.
										5381	5866	
										5333	5333	
V	1	0	1/2	1/4	1/4	1	3.75	⌐	⌐	5720	3640	NOTE THE GREATER UNIFORMITY OF RESULTS WITH THE INCREASED NUMBER OF LAYERS.
										4870	3580	
										4960	4550	
V	3	24	1/2	1/4	1/4	1	3.75	⌐	⌐	4610	4040	
										4310	5530	
										5030	5030	
V	6	24	1/2	1/4	1/4	1	3.75	⌐	⌐	4480	4340	
										4720	4510	
										4690	4650	
V	1	0	1/2	1/4	1/4	1	3.	⌐	⌐	3770	3840	THIS GROUP ALSO SHOWS TENDENCY TO LOWER STRENGTHS IN 6" MASSES
										4890	4370	
										4280	4240	
V	6	24	1/2	1/4	1/4	1	3.	⌐	⌐	5170	4580	SHOT VERTICALLY AT ONE OPERATION. ALSO COMPARE V-1-0 WITH H-1-0 BELOW.
										4590	5260	
										5260	5450	
H	1	0	1/2	1/4	1/4	1	3.	⌐	⌐	4850	4740	THIS SET SHOWS POSIBILITY IN HORIZONTAL SHOOTING WHEN REBOUND IS NOT ALLOWED TO ACCUMILATE.
										5490	4390	
										4920	4930	
V	6	24	1/2	1/4	1/4	1	3.	⌐	⌐	5220	5530	THE 1/2 PORTION OF SAND THRU #8 ON #12
										5190	4920	
										4130	4700	
V	6	24	SEE	NOTE		1	3.	⌐	⌐	5820	4010	POTOMAC RIVER SAND AS IT CAME
										4530	4820	
										4780	4170	
V	6	1	1/2	1/4	1/4	1	3.	⌐	⌐	5320	5030	SIX LAYERS - EACH TROWELLED TO SIDEWALK FINISH AND ALLOWED TO STAND ONE HOUR
										5020	5230	
										5510	5610	
V	6	24	1/2	1/4	1/4	1	3.75	⌐	⌐	5455	5487	THE TWO 1/4 PORTIONS OF AGGREGATE USED IN THESE SETS WERE REBOUND.
										6000	6299	
										5422	6007	
V	6	24	1/2	1/4	1/4	1	2.5	⌐	⌐	6444	6732	
										6060	5934	
										6444	5855	
H	1	0	1/2	1/4	1/4	1	2.5	⌐	⌐	5249	3728	
										3866	4364	
										4522	4146	
H	6	24	1/2	1/4	1/4	1	2.5	⌐	⌐	5000	4460	
										5500	5080	
										⌐	6420	L.A. CEMENT GUN CO.

RESULTS OF COMPRESSION TESTS ON GUNITE AND HAND PLACED MORTARS.

Conducted by STAATLICHEN MATERIALPRÜFUNGSAMT, BERLIN-DAHLEM, (*German Government Materials Testing Bureau*)

Series No.	Material Propelled Against Surface in Direction of Arrow	Load Applied Parallel or Perpendicular to Plane of Lamination	Material Tested	Average—Five Samples	
				Kilograms per sq. cm.	Pounds per sq. in.
1	⟶ Two Layers	Parallel	Gunite 1:4	450	6398
2	⟶ Two Layers	Perpendicular	Gunite 1:4	461	6565
3	⟶ One Layer	Perpendicular	Gunite 1:4	398	5659
4	⟶ Two Layers	Perpendicular	Gunite 1:5	376	5346
5	⟶ Two Layers	Perpendicular	Gunite 1:6	355	5047
6	↓ Two Layers	Parallel	Gunite 1:4	516	7336
7	↑ Four Layers	Parallel	Gunite 1:5	553	7863
8	Hand Placed Mortar		1:4 Mortar	164	2332
[9]			1:4 Mortar	168	2389

Gunite samples were approximatly 2¾ inches thick, cut from Gunite slabs 4 to 6 sq. ft. in area. The Gunite slabs were shot July 5, 1923, and they were subjected to test Sept. 24, 1923. The hand placed mortar samples contained 7 to 8% of mixing water, by weight and the mortar was thoroughly tamped into the moulds.

(*Reprinted from The American Architect*)

4th. RESISTANCE TO ABSORPTION OR PERCOLATION.

The characteristics of density and strength make "GUNITE" an especially desirable material to use where structures will be subjected to destruction from the attack of salt water, alkalies, or acids. Concrete generally has a rather high percentage of porosity with the result that the introduction of water into the interior pores allows chemical action to take place inside the concrete with the resultant formation of crystals and the breaking down of the structure from expansion. "GUNITE" prevents this infiltration and consequently prevents the formation of either chemical crystals or crystals formed by frost action.

It is this resistance to percolation that has made the use of "GUNITE" so desirable for lining of reservoirs and irrigation ditches. Thin slabs of "GUNITE" directly against the earth are becoming a standard method of such construction.

Similarly Mr. J. R. Baylis in a paper read before the American Society of Civil Engineers, *Vide Transactions A. S. C. E., April, 1926,* (which paper was awarded one of the annual prizes of the society) showed that the constant inflow and outflow of even pure water dissolved the cement and caused a more or less rapid destruction of the concrete. This destruction is especially marked at the water line of sewage disposal or water filtration plants.

5th. LOW WATER—CEMENT RATIO.

The qualities of "GUNITE" above referred to are largely due to two reasons:—

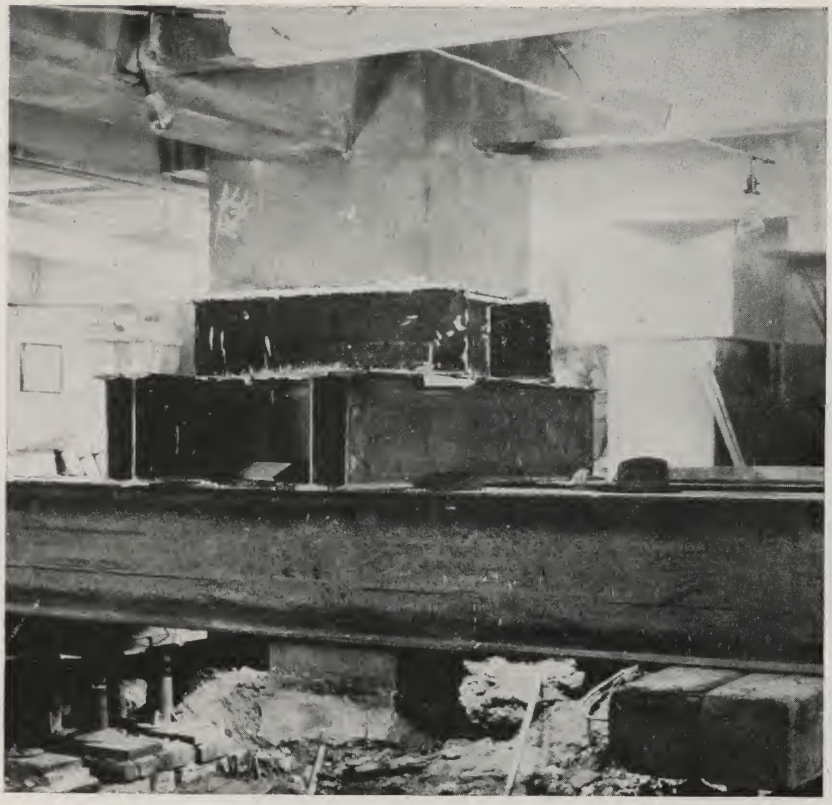
(a) The method of placing under pressure, and not in forms, results in the natural rejection of excess materials.

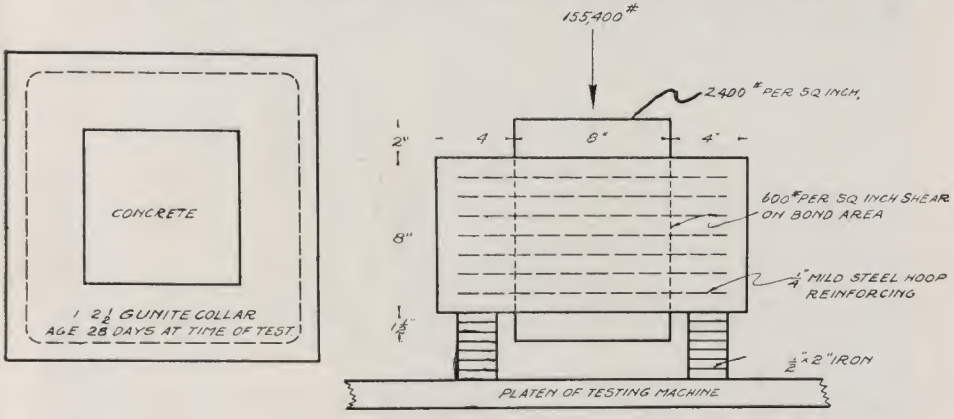
(b) The water content is reduced to a point where only sufficient water can be used to insure proper hydration of the cement.

The illustrations in the following pages show how extensively these various features have been employed to construct, restore, and maintain masonry structures of all types.

This photograph illustrates a method developed by the engineers of the Pennsylvania R. R. for protecting the bottom of concrete bridge floors by using preshot "Gunite" arches for forms.

ADHESION OF GUNITE

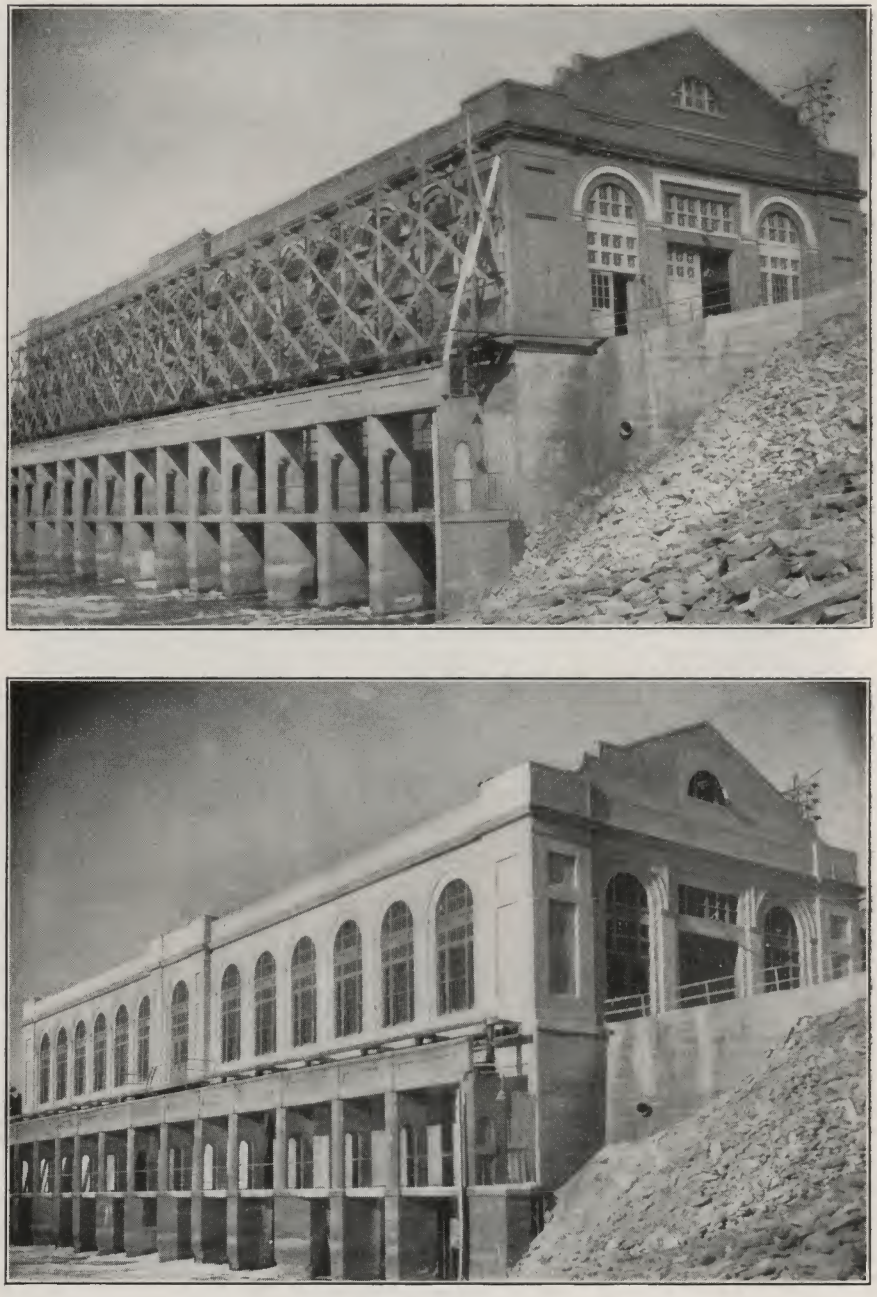




These photographs refer to the text regarding "Adhesion" and show results of tests made by the Univ. of California. (*Vide Page 2.*) The upper photograph shows a column in the Dividend Building being underpinned with the weight carried on the "Gunite" collar shot around the column. (*Vide-American Architect, Apr.* 23, 1924, *also Oct.* 10, 1925.) Note the bottom of the column exposed.

Lower. Showing details of test.

REPAIRS BRICK MASONRY



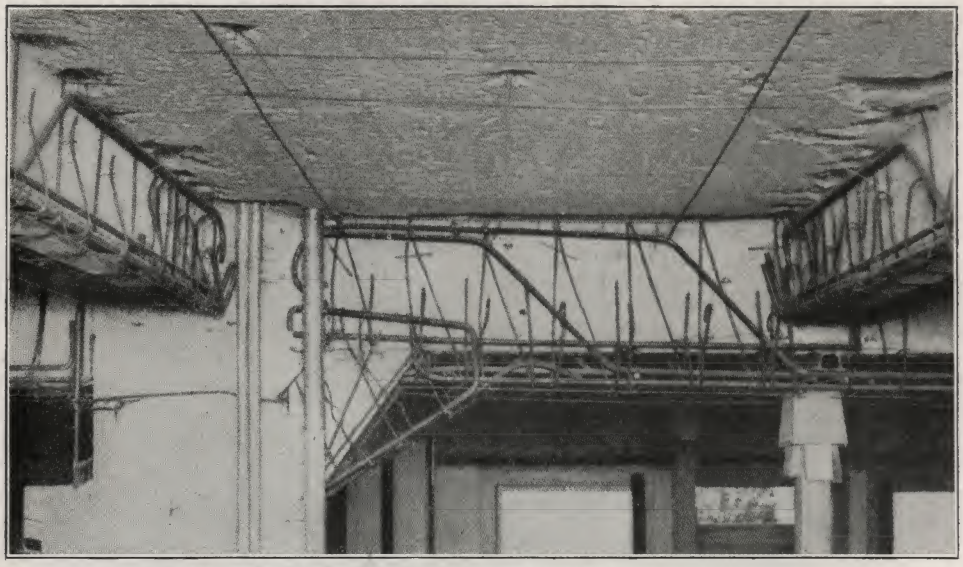
Power House of WISCONSIN POWER and LIGHT CO. at KILBOURNE, WIS., showing brick walls before and after they were restored by a coat of reinforced "GUNITE". Work done by our Contract Department. This work is illustrative of how successfully architectural effects can be maintained with "GUNITE".

BRICK MASONRY REPAIRS

Upper. Old brick building at Meriden, Conn. in 1922, showing condition of brick, also showing "shooting strips" in place around windows, star anchors and coping, prior to "Guniting".

Lower. Same building after "Gunite" completed. A recent examination shows this building to be in perfect condition and is an excellent example of how successfully "Gunite" can be employed to make such restoration.

REPAIRS TO BUILDINGS



Upper photograph shows method of strengthening the girders and floor slab of the Heard Building, Phoenix, Ariz. This concrete building was increased in strength by building up the columns, girders and slabs from a 60-lb. designed occupancy to accommodate a 200-lb. occupancy.

Such work as this is common practice.

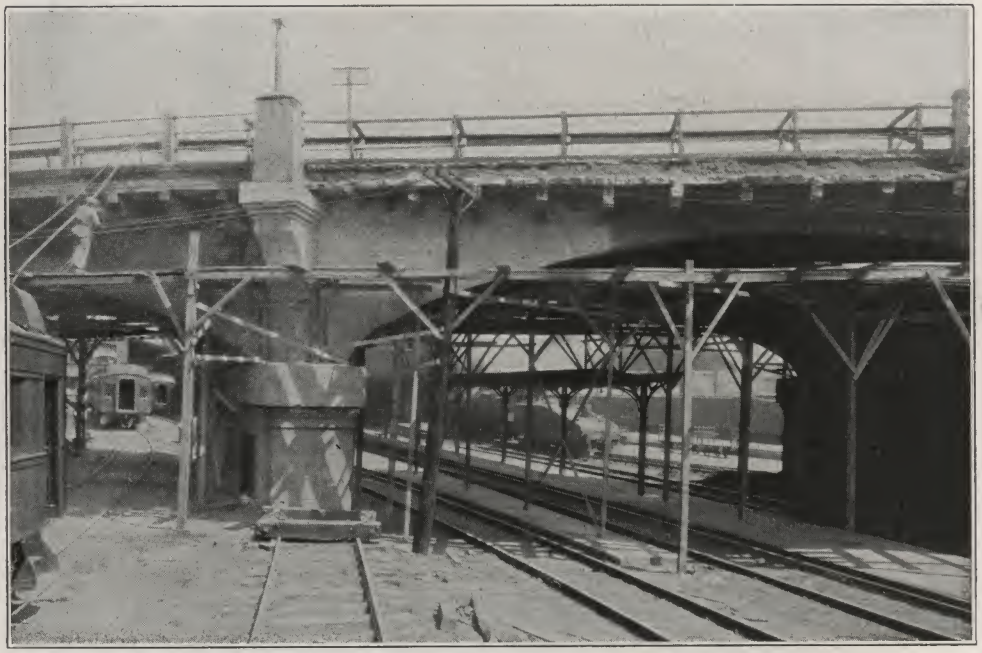
Lower. Restoring the McDougald Warehouse at Duluth, Minn., where the concrete had been seriously affected by fire. Photos show before and after the application of the "Gunite".

These photographs illustrate restoration made by our Contract Dept. of School No. 68, Buffalo, N. Y. This building was condemned before completion due to frozen concrete and other defects. Careful study was made of each member and slab, and each was treated to correct its individual deficiency. Tests made of the building after the repairs were completed showed it to be stronger than called for in the original design, and the success was so marked that subsequently the Buffalo Board of Education has used this method for restoring other schools.

Upper. Building shored and columns cut back beyond steel reinforcement before applying "GUNITE".

Lower. Repairing corridor slab by strengthening from below.

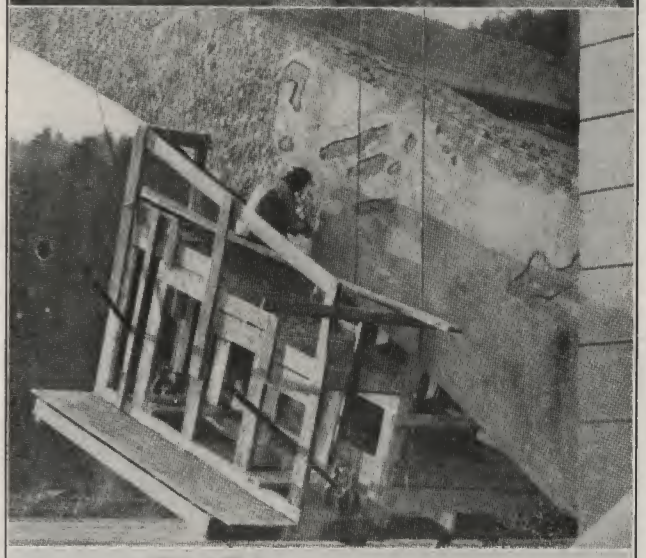
BRIDGE REPAIRS

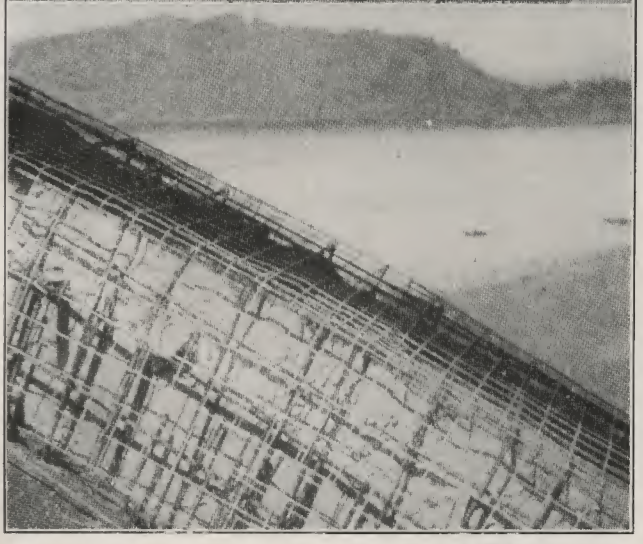


Upper. Arch Bridge at Mulberry St., Harrisburg, Pa. over tracks of Penn. R. R. Work done in 1917, and repaired portion is now in excellent condition

Lower. Old masonry arch near Lancaster, Pa., restored in 1917.

These repairs (both done by our Contract Department) are excellent illustrations of a large number of similar structures that have been preserved by the use of "GUNITE".





BRIDGE REPAIRS

These photographs show the details of reconstruction of the new reinforced concrete arch bridge over the Klamath River, California, as described in *Eng. News Record, Sept. 1st, 1927.* This new structure was highly representative of the difficulties of pouring concrete under adverse conditions and the "GUNITE" repairs indicate how easily and satisfactorily it is possible to bring a structure of this type to its fullest efficiency.

Upper. Repairing arch rib.

Center. Details of chipping concrete to insure full bond between concrete and "Gunite".

Lower. Rib chipped and reinforcing mesh placed ready for "Gunite".

BRIDGE REPAIRS

These two photographs illustrate one of the most outstanding examples in the U. S. of the successful use of "GUNITE" restoration. Two bridges in Nashville, Tenn. over the Cumberland River at Jefferson St. and Sparkman St. were erected in 1911. In 1922 the condition of the concrete (due largely to faulty aggregates) was so serious as to cause the City Engineer to condemn both bridges. They were entirely rebuilt with "GUNITE" with a saving of over one million dollars.

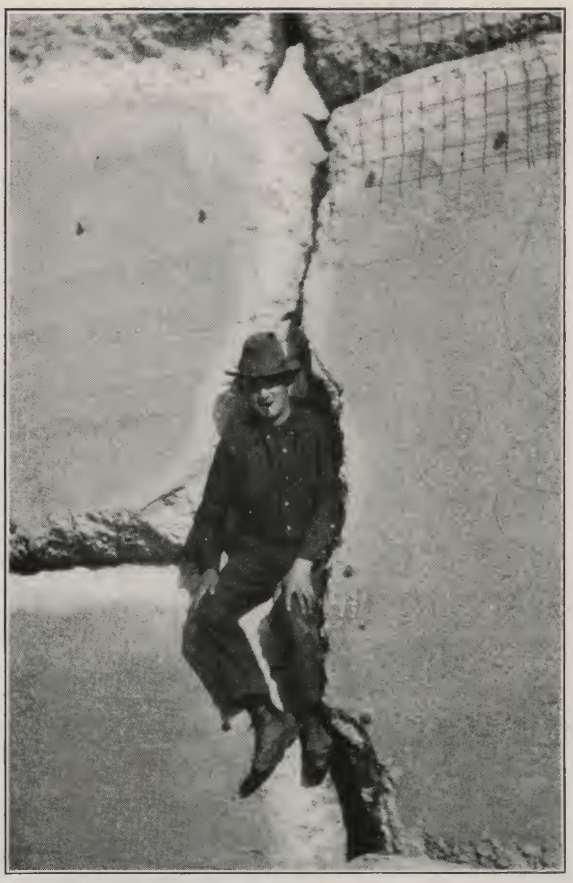
Upper photograph shows column and fascia girder restoration. Lower photograph shows the extent to which it was frequently necessary to remove defective concrete.

CONCRETE REPAIRS

Upper. Showing method of waterproofing grain silos of elevator at Weiser, Idaho. Such repairs are frequently made to insure protection of the grain against damp conditions due to the porosity of concrete.

Lower. Repairing concrete coal handling plant at Groveland, N. Y., 1924. Such plants, as well as concrete roundhouses, are subjected to severe conditions and "Gunite" repairs are standard practice. **Both of these repairs were made by our Contract Department.**

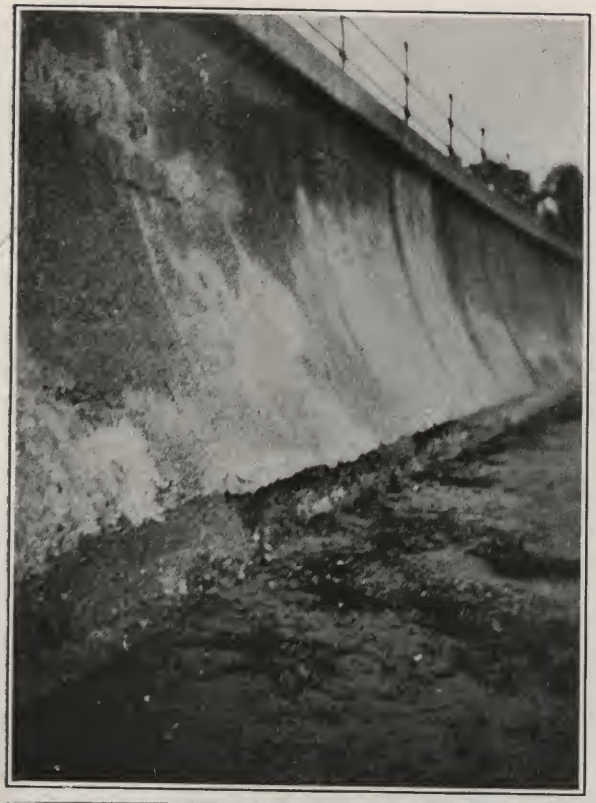
One of the most striking illustrations of successful repairs of concrete structures is the Phoenix Jetty at Southampton, England, where, not only was service on the pier maintained but, according to the engineers, about $100,000 was saved by using "Gunite".



CONCRETE REPAIRS

Upper. Showing condition of dam at Lochmere, near Laconia, N. H., after chipping out disintegrated concrete. This dam was successfully restored by our Contract Dept.

Lower. Showing method of restoring piles and bottom of slab of pier of Navy Dept. at Key West, Florida. Such repairs are standard practice of the Navy Dept.



REPAIRS ON CONCRETE SUBJECTED TO SEA WATER

These two photographs are of the concrete wall along the ocean front at Lynn, Mass.

In 1911 the condition of this wall was such as to demand immediate repair. "GUNITE" (although at the time the "Cement Gun" was only about a year old) was used for facing the wall above the beach level.

The upper photograph shows the present condition of this wall. The beach level has receded and shows clearly how the "Gunite" has protected that portion which was covered. Below the "Gunite" level the concrete is badly deteriorated, in some places having been eaten away to as deep as 18″.

The lower photograph is that of a portion of this wall where the concrete was destroyed by action from below the "Gunite," allowing a large piece to fall out. Note that this large block of concrete is apparently held together by the thin layer of "GUNITE."

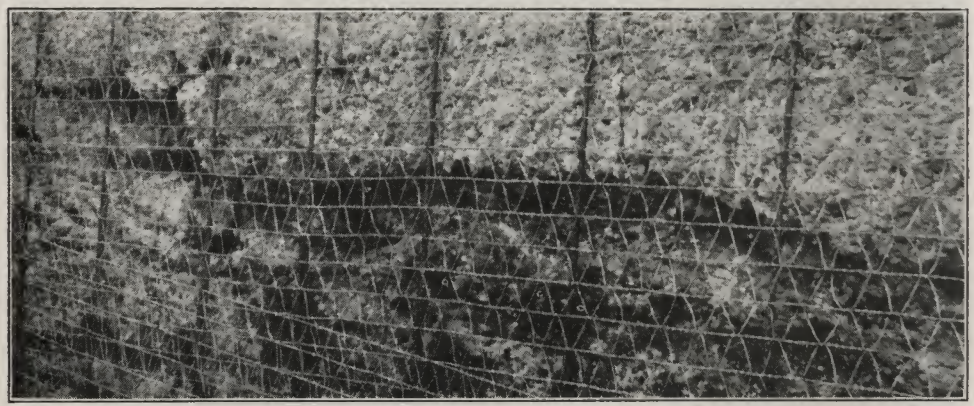
"Gunite" is positively resistant to salt water action and is consequently used not only to protect concrete under such conditions but also as a coating over wooden piles before driving. Write to us for information about such use in Porto Rico, Tacoma, and elsewhere.

DAM REPAIRS

Upper. Showing condition of down stream face prior to repairing.

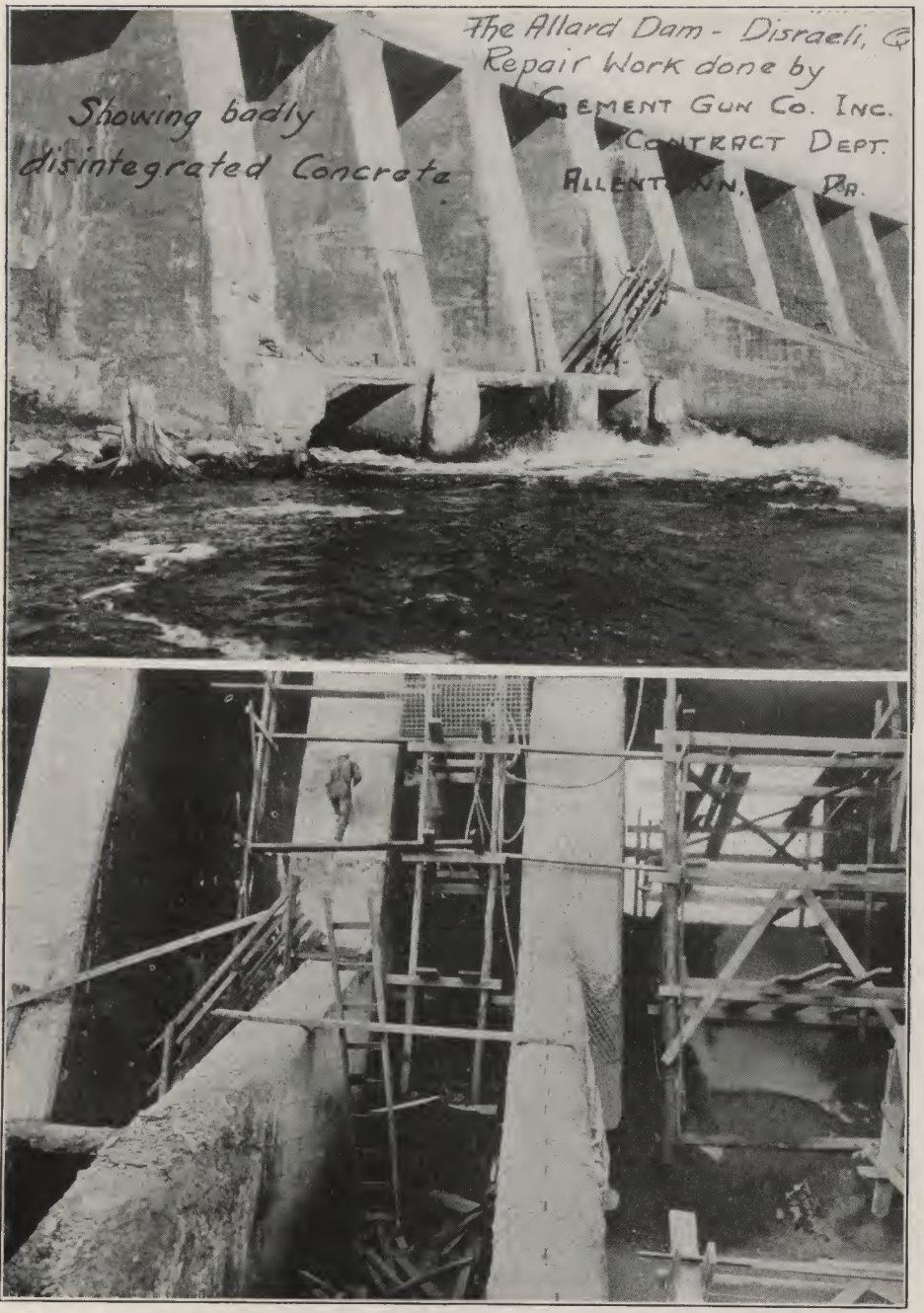
Center. Up stream face being repaired.

Lower. Dam after repairs completed. Work done in 1921 and recent examination shows dam in perfect condition.



CANADA POND DAM NEAR PROVIDENCE, R. I.

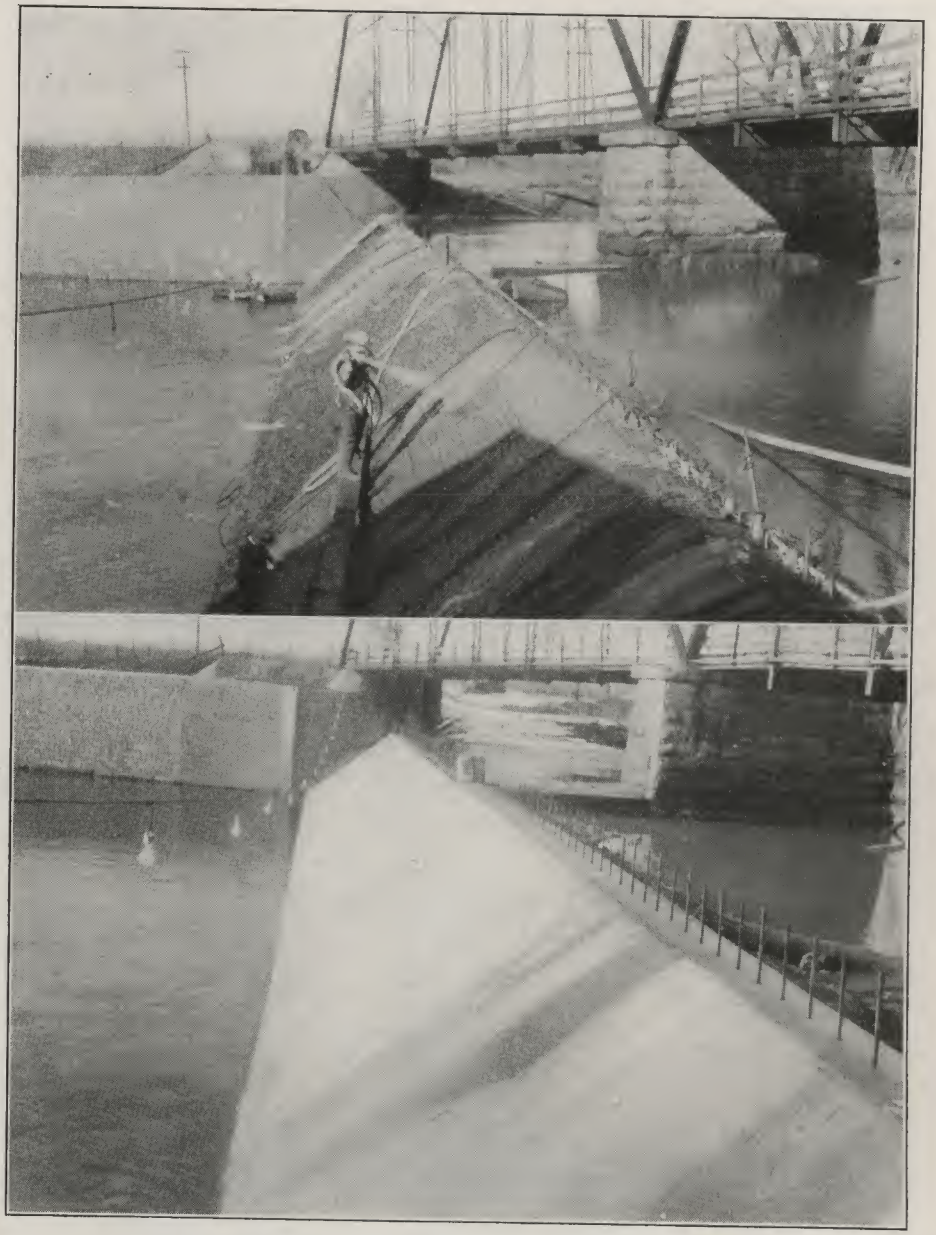
DAM REPAIRS



These photographs of the Allard Dam, Disraeli, Quebec, are illustrative of the extent to which numerous dams have disintegrated, and also show the methods used in restoring with "GUNITE". Even those places where the concrete is broken away for as much as 18" are restored to original lines by building out in successive layers.

Work done by our Contract Dept., and described in Canadian Engineer Jan. 21, 1930.

DAM REPAIRS



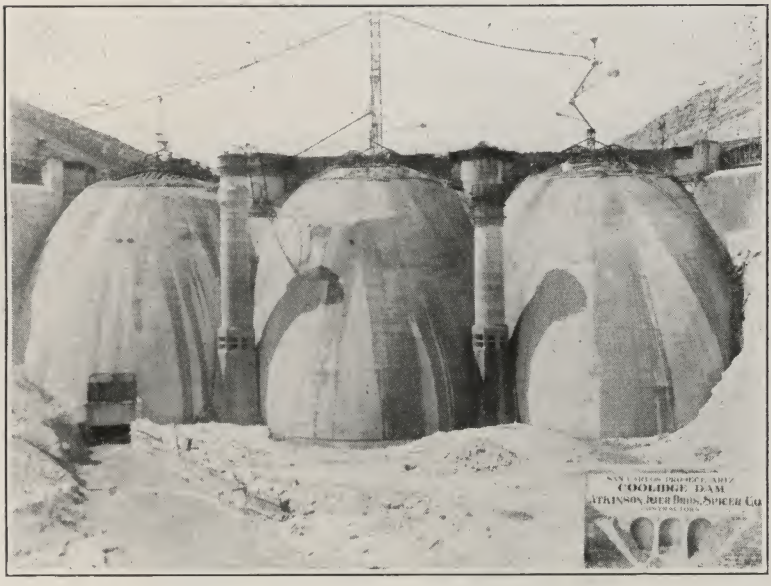
Dam of Iowa-Nebraska Power Co., at Holmesville, Neb.

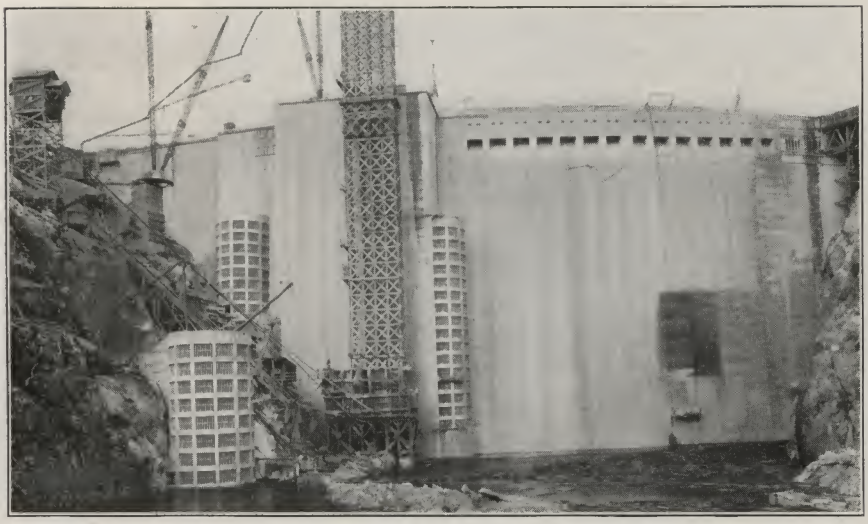
Upper. Dam under repair showing how all loose and disintegrated concrete is removed; surface sand-blasted; reinforcing mesh placed; and "GUNITE" applied.

Lower. Completed repairs.

This work was done by our Contract Dept. and is fully illustrative of how numerous other dams have been similarly restored.

WATERPROOFING AND PROTECTING DAMS





Protecting the up stream face of dams by a coating of "GUNITE" was first adopted at Elephant Butte. The success was marked and similar specifications were adopted for the O'Shaughnessy (Hetch-Hetchy) Dam, (lower photograph). These specifications read *"As an additional precaution against leakage the up stream face and appurtenant structures shall be covered with mortar applied by means of a "Cement Gun."*

Upper. Coolidge Dam, Arizona. This very extraordinary dam is protected against leakage by a coating of reinforced "Gunite" on the up stream surface.

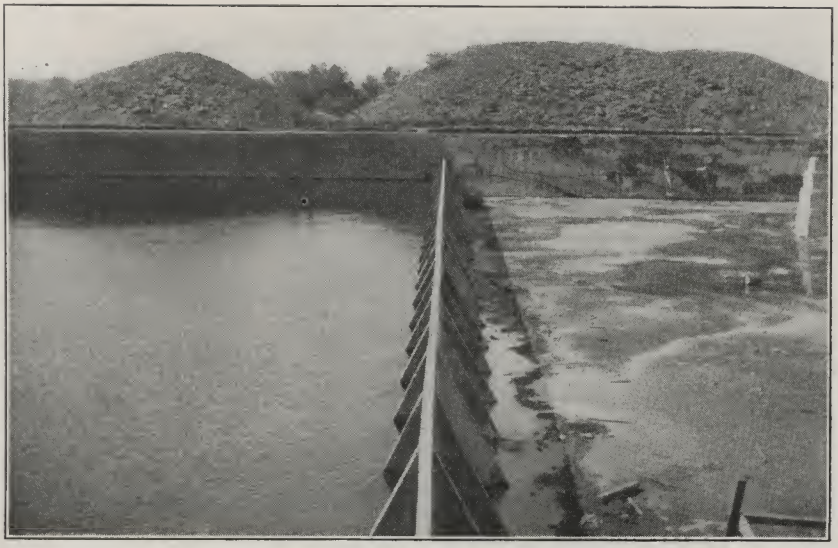
There are a number of dams in this country, Canada, and abroad where similar methods have been used. Two very recent and notable examples are the large dam in the Nidd Valley, Yorkshire, England, and the Chendoreh Dam of the Perak Hydro Development, Straits Settlement.

DAM AND BANK REVETMENT

Upper. Photograph showing method of construction developed by Mr. Frank O. Ray, City Eng., Colorado Springs, Col., in constructing the South Ruxton Dam. Rubble Masonry, of proper thickness was built up and the surfaces covered with a heavy layer of reinforced "GUNITE", thereby getting positive protection against seepage.

Lower shows method of protecting riprap slopes against erosion. This method was employed by the Wheeling & Lake Erie R. R. near Brilliant, Ohio, in 1917 and a very recent report from the engineers is that: "*We have never had any trouble from this fill although subjected to severely erosive conditions.*

RESERVOIR REPAIRS



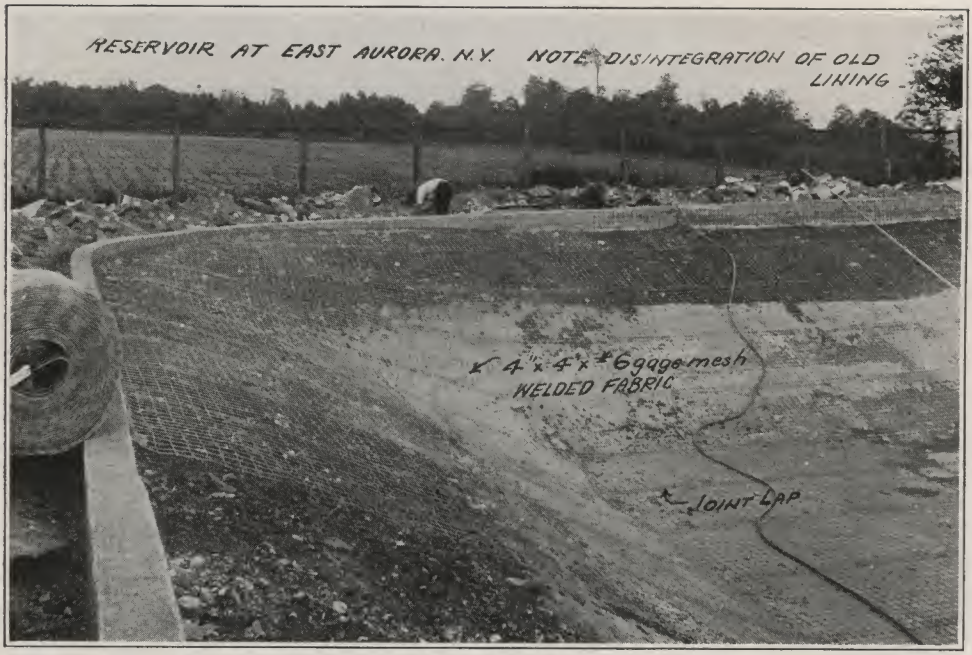
Upper. Showing half of reservoir of Clear Spring Water Co. at Cementon, Pa. empty and being repaired; other half with water behind newly completed dividing wall. This wall was 4½″ thick at bottom—2½″ thick at top reinforced equally both sides; with buttresses 8′ centers. By this method of construction it was possible to refill the reservoir in two weeks.

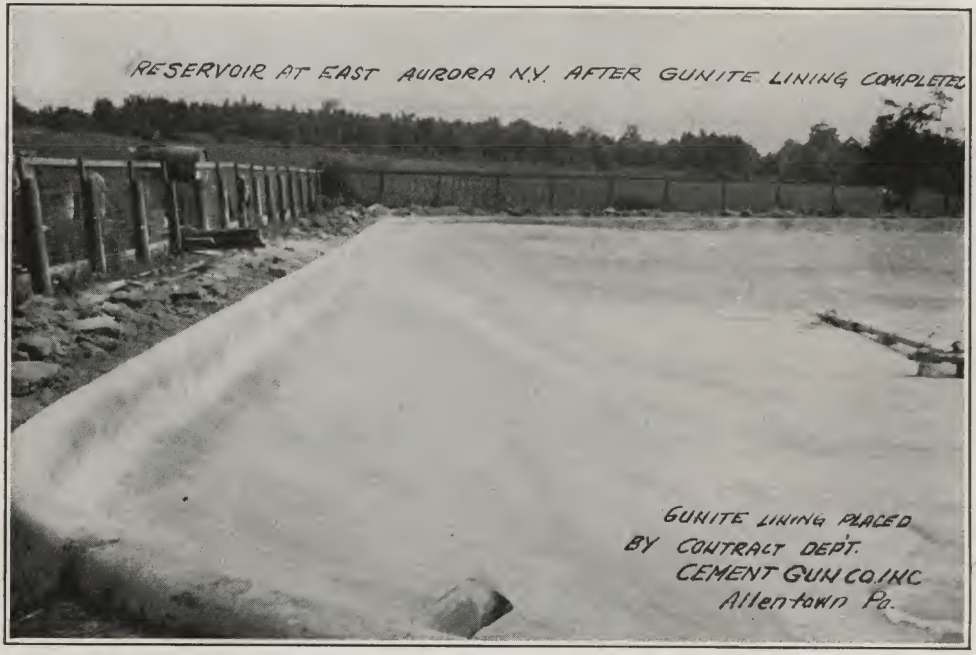
Lower. Restoring slopes of brick lined reservoir at Wilmington, Del. The leakage from this reservoir prior to "Guniting" was so great that the water level could not be raised to within 15′ of top.

Both of these linings were placed in 1923 and today are in perfect condition.

Work done by our Contract Dept.

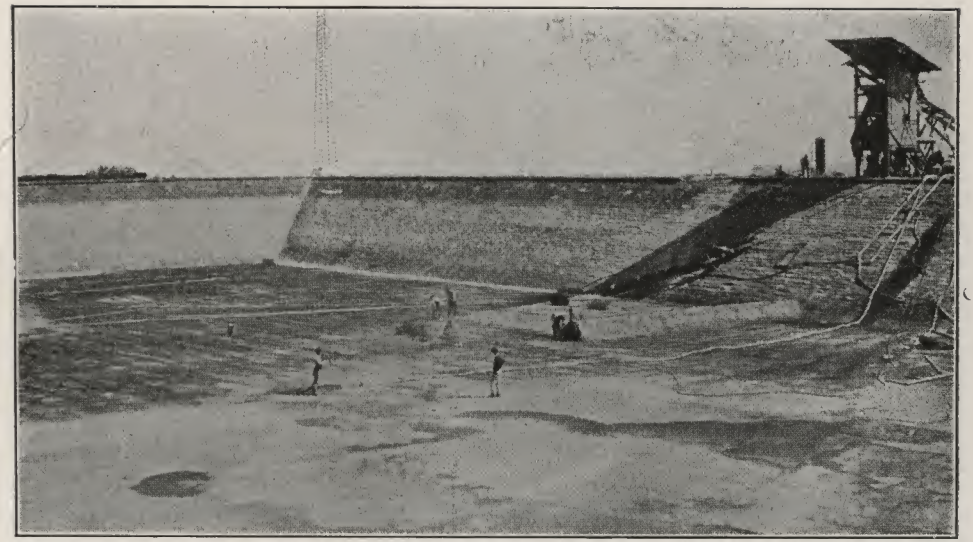
REPAIRS OF RESERVOIRS





This reservoir at East Aurora, N. Y. (lined in 1925) is very typical of the faulty condition to be found in a great many concrete lined reservoirs and the correction of these conditions by the use of a "GUNITE" lining.

REPAIRS OF RESERVOIRS



Upper. Repairing Herron Hill Reservoir, Pittsburgh. This work was done in 1919, and has been so satisfactory that other reservoirs in Pittsburgh have been similarly lined. *For test of water-tightness see Eng. News Record, Nov. 25, 1920.*

Lower. Dividing wall and slope of Payson's Park Reservoir, Cambridge, Mass. This work was decided on after the engineers had made a careful examination of the Pittsburgh reservoirs.

The latest illustration of successful restoration of concrete lined reservoirs is the 20 million gallon reservoir at Kilbourne Park, Milwaukee, where in 1929 our Contract Dept. placed a lining of 180,000 sq. ft. in less than six weeks. The test against leakage showed remarkable results.

GUNITE LINED RESERVOIRS

(a)

Upper. Lining reservoir belonging to Anaconda Copper Co., at Great Falls, Montana, by placing "Gunite" directly against the earth. This was the first reservoir to be lined in this manner. Work done in 1916, and a recent report says: *"We have not been bothered with any leaks, and when cleaned in 1927 the reservoir was in good condition."*

Lower. "Gunite" lining against earth of the High Pressure Reservoir on the Spavinaw Project, Tulsa, Okla. Work done in 1922.

Note particularly that all "Gunite" linings of reservoirs are placed without expansion joints. "Gunite" lining directly against the earth is now standard practice.

WATERPROOFING AND RUSTPROOFING RESERVOIRS

These two photographs show the attitude of the Water Dept. of Cincinnati toward "GUNITE". Upper. Steel tanks lined with "Gunite" and treated externally for architectural effects. Lining of steel towers is resorted to by other engineers to protect against corrosion. (*Vide-Water Works Engineering, May 8, 1929.*)

Lower. Eastern Hills Reservoir. These concrete walls were protected on both sides with "Gunite" to insure watertightness. In addition to these two illustrations these engineers have relined the large reservoir at Eden Park and have also specified "Gunite" lining directly against the earth in several new reservoirs.

DAM REVETMENT

Upper. Thin "Gunite" slab on upstream face of Happy Valley Water Company Dam, Shasta County, Calif., placed in 1917. A report dated Jan. 1930 advises that *"The "Gunite" face on the upstream face of the dam is holding up in very good shape. In fact the only weakness developed has been a few bulges caused by expansion"*.

Lower. "Gunite" slab on upstream face of dam of Lewiston, (Idaho) Orchards Irrigation District. This work was done in 1922 and a report dated Jan. 1930 says: *"Gunite" used on our reservoir is satisfactory—'Gunite' very dense and tough"*.

Note that both of these linings are in very cold climates and are subject to very severe conditions.

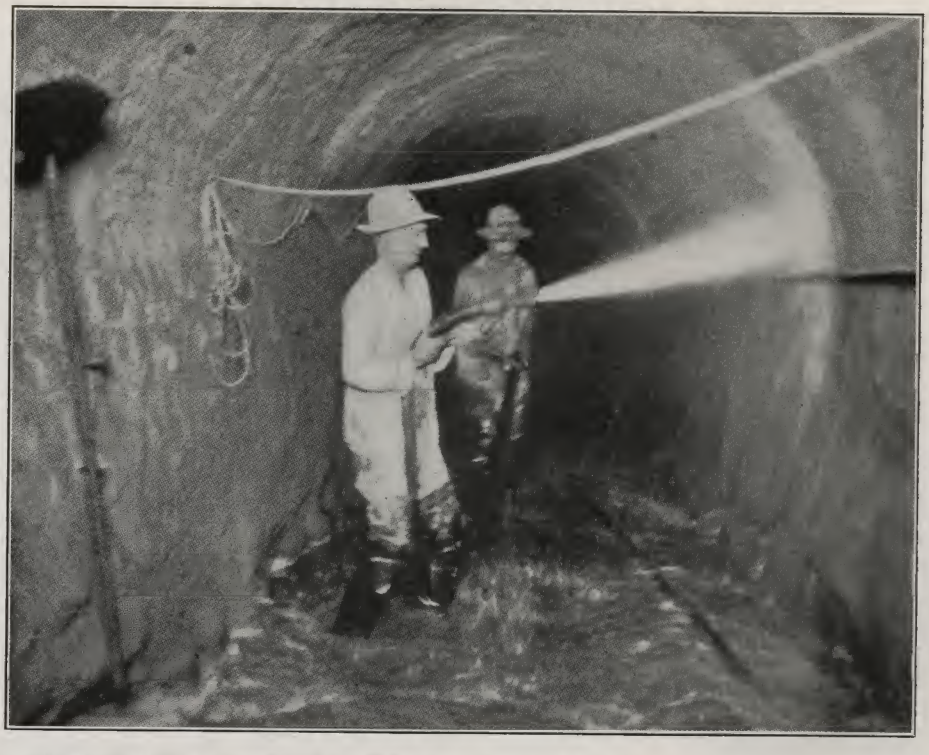
BANK REVETMENT

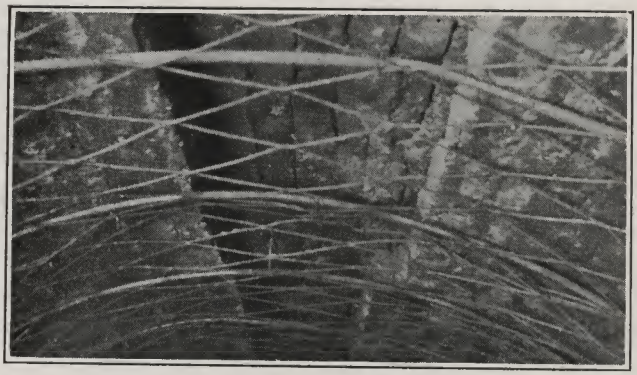
Upper. "Gunite" revetment Los Angeles Flood Control District consisting of solid mat on slopes and flexible mat of "Gunite" blocks on bottom. This photograph shows only two rows. This work described in CONSTRUCTION METHODS, OCTOBER 1929.

Lower. "Gunite" revetment Buffalo Bayou, Houston, Texas. This mat was shot over fresh fill and although the bank has settled several inches under severe flood conditions the "Gunite" has remained intact.

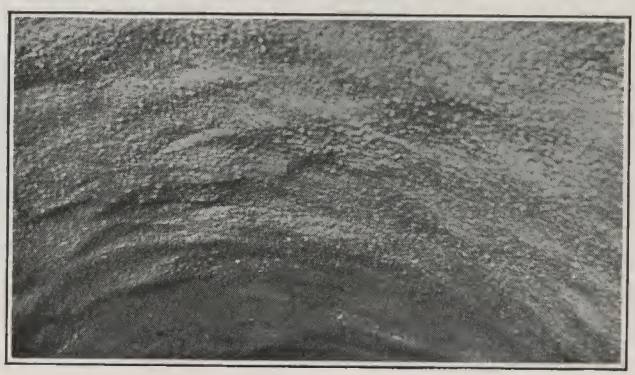
This work was done by our Contract Department.

RELINING SEWERS





Upper. Relining sewer in St. Louis, Mo. This city has relined several miles of old brick sewers. This decision was reached after having placed a sample section in 1913 and noting the very satisfactory results obtained. Complete information was given in a report published in 1927 by Mr. W. W. Horner Ch. Eng. in which statement is made of large savings effected.



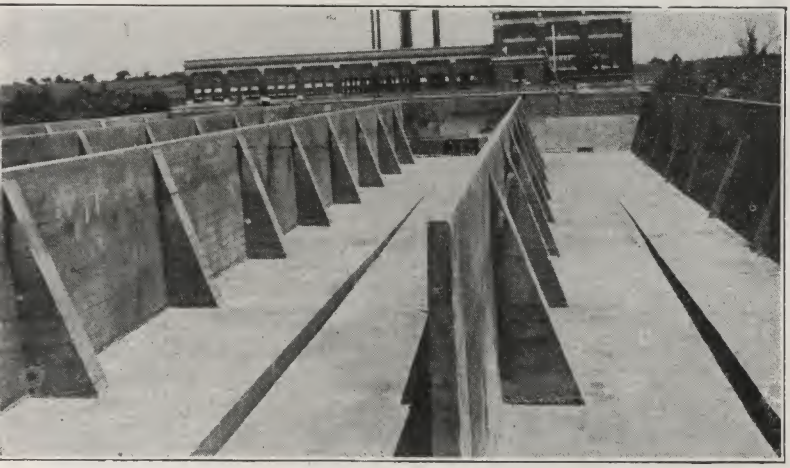
Center. Crown of brick sewer in Dayton, Ohio, where a number of sewers have been restored. Note the method of reinforcing the arch.

Lower. Completed sewer at Dayton.

New York, Indianapolis, Richmond, Va., and other cities have done a good deal of similar repair work. Write to us for complete details.

GUNITE IN SEWAGE DISPOSAL PLANTS

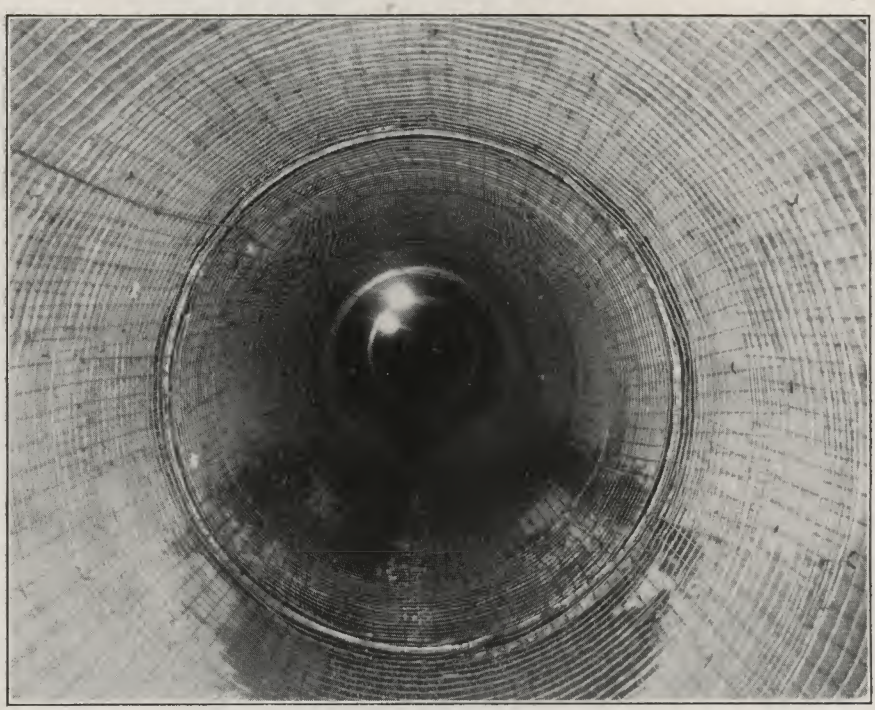
Upper. Tanks at Oklahoma City prior to "Guniting". Center. Same after repairs completed.



Lower. Building Baffle walls of "Gunite" at Elgin, Ills.

This method is now standard practice of numerous engineers. "Gunite" eliminates all danger of destruction by the acids in sewage.

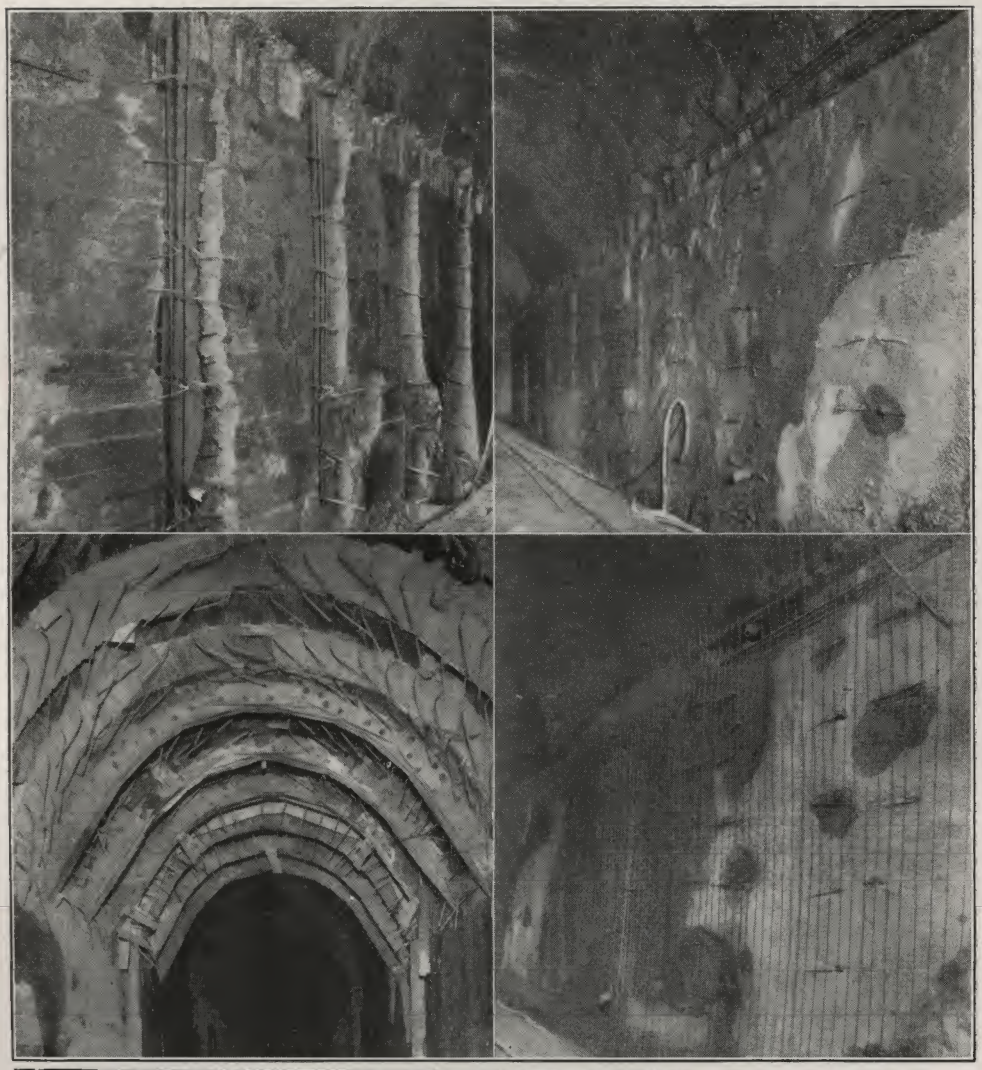
TUNNEL LINING

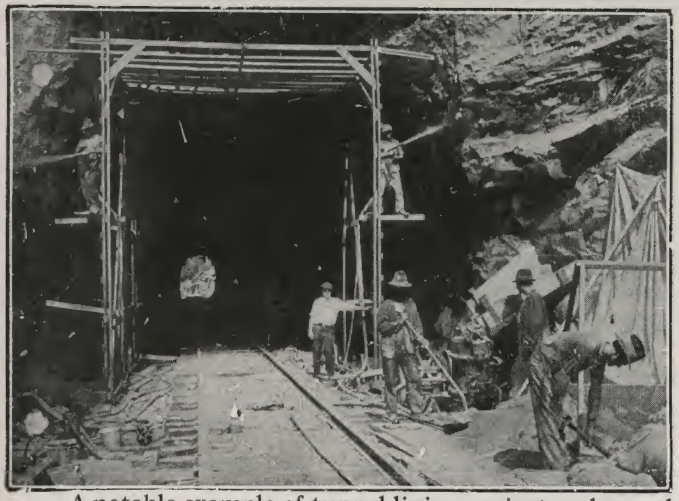


These photographs show the reinforced "GUNITE" lining of the concrete tunnels at the Montebello Filters in Baltimore, Md. These new tunnels leaked very badly on acceptance test, but after being lined, successfully withstood the most severe test. Note the excellent surface obtained. It is of interest to note that this finish was the standard demanded by the engineers in the specification for lining the Toronto Water Tunnel. Let us send you a copy of this specification.

This work at Baltimore was done by our Contract Department.

TUNNEL REPAIRS





Repairing concrete lined Tunnel on the Missouri Pacific R. R. in Arkansas.

Upper left. Showing slots in wall for columns to give increased strength.

Upper right. Studs filled with "Gunite".

Lower left. Building arch ribs.

Lower Right. Mesh in place for finished lining. This work done by Gunite Concrete Construction Co., Kansas City, Mo.

Lower. Lining Tunnel at Unionville, Ind., (Ill. Cen. R. R.) directly against rock.

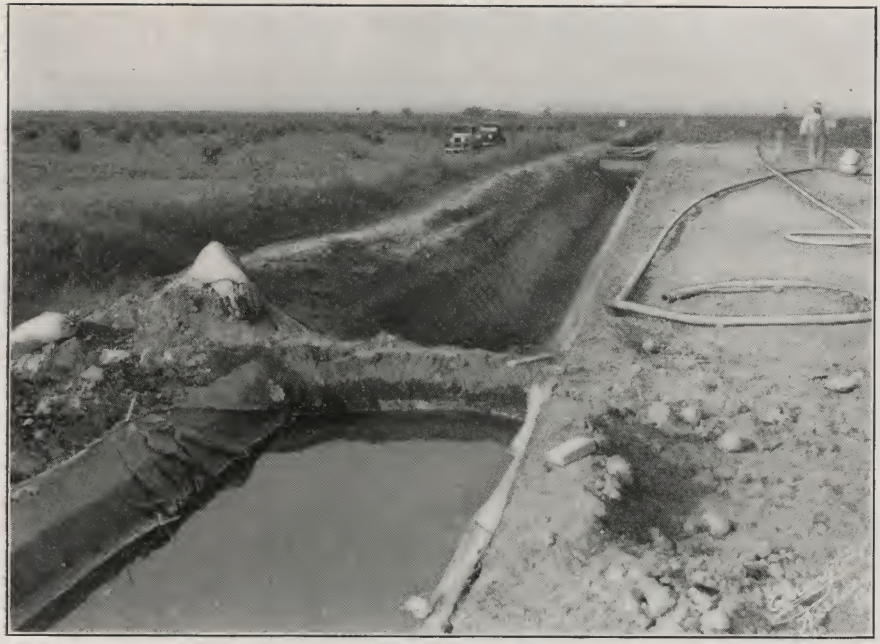
A notable example of tunnel lining against rock was the Moffatt Tunnel where about 2½ miles of tunnel was lined.

LINING IRRIGATION DITCHES

These photographs illustrate two of the stages in the lining of irrigation ditches in the Rio Grande Valley, near Mission, Texas. Note the circular bottom, which results in cheaper construction and greater hydraulic efficiency. Also note the alignment strips at top and the method of finishing.

An examination of this work was made recently by a prominent irrigation engineer whose comment was *"I did not beleive it possible to obtain a lining with "Gunite" of such high flow coefficient."*

LINING IRRIGATION DITCHES



Upper photograph shows method of curing. Lower photograph shows completed lining. "GUNITE" LININGS have meant saving of water, economy of operation, (ditch cleaning etc.) **and absolute freedom from seepage and destruction of ground.** This Texas work was done by OUR CONTRACTING DEPARTMENT which also lined 3½ million feet at Higley, Arizona.

Write to us for proper specifications for linings in both hot and cold climates.

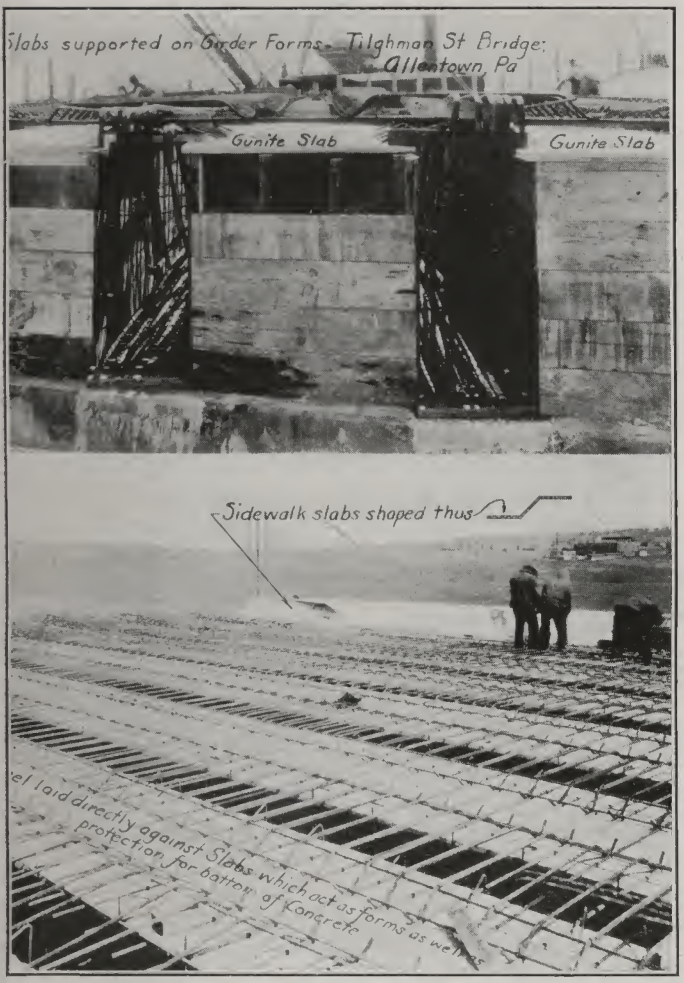
LINING IRRIGATION DITCHES

These photographs tell a pictorial story of a very unique ditch construction in rough and rocky country near Reno, Nevada. Note the method of side hill work by building dry walls and covering with "Gunite." This ditch was built in 1917 and from recent reports is in *"very good condition"*. Mr. Harry Chism, City Engineer, Reno, examined this ditch about three years ago in the winter time and stated in his report:— *"This ditch is subjected to great range in temperature and although now in use for several years I did not see any evidence of the "Gunite" failing or breaking off. I think this is very remarkable as the frost here has a very bad effect on most thin concrete work where water can get under it"*.

SIMILAR "GUNITE" LININGS IN OTHER VERY COLD CLIMATES HAVE BEEN EQUALLY SATISFACTORY. A NOTABLE ILLUSTRATION IS THE DITCH ON THE COVE PROJECT AT BILLINGS, MONTANA, WHICH WAS LINED BY P. W. HASTINGS CO. IN 1924, AND HAS BEEN SO SUCCESSFUL THAT A LARGE AMOUNT OF SIMILAR WORK HAS BEEN DONE IN THAT VICINITY.

PROTECTING NEW CONCRETE

(See also cut on page 4)

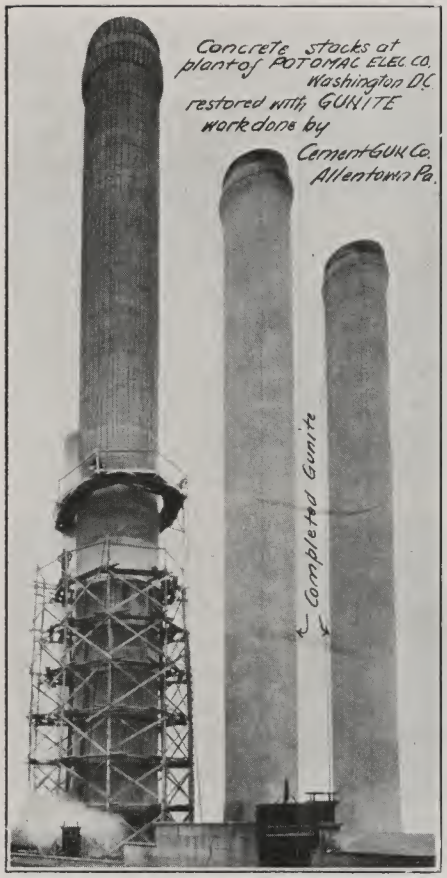


These photographs illustrate methods now in general vogue for protecting concrete with "GUNITE" in original construction. Further illustrations are given on page 19 showing that the upstream surfaces of dams are given protective coating to insure waterproofness.

Upper. One of the approach spans of the reinforced concrete bridge over the Lehigh River at Allentown, Pa. All of the bottom of the concrete is protected against locomotive blast action by preshot slabs used as forms and by "GUNITE" over the girders.

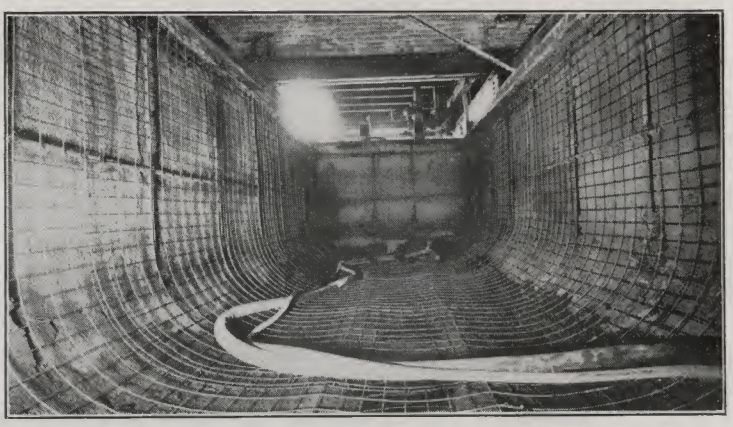
Lower. Concrete blocks used as jetty near Palm Beach Fla., covered with reinforced "Gunite" in 1925 and in perfect condition today.

Both of above contracts executed by our Contract Department.



Left. Concrete Stacks at Potomac Edison Co., Washington, D. C.
Right. Brick Stack at Bogalusa Paper Co., Bogalusa, La.

"Gunite" is very extensively used not only to repair concrete and brick stacks as illustrated above, but also to build self supporting stacks around old steel stacks.



Lining of bunkers in power plants with "Gunite" is standard practice and the lower photograph showing a "Gunite" lining to a "Digester" at the Thilmany Paper Co., is an excellent illustration of the resistance of "Gunite" to acid conditions.

CEMENT-GUN
TRADE MARK

Its Use in Power and Steel Plants

Especially in Making

Repairs to Refractory Surfaces

Shooting a furnace lining

During the past several years the extensive and successful use of this machine in the repair of furnace linings under various conditions, justifies us in making the statement that furnaces of all types where clay brick are used can be positively and economically maintained.

The success of this method of maintenance is attributed by refractory engineers to the fact that the coating of ground, thoroughly burned, fire brick placed with the pressure obtained by the use of the "Cement Gun" insures a homogeneous and refractory surface better than is ordinarily obtained with fire brick.

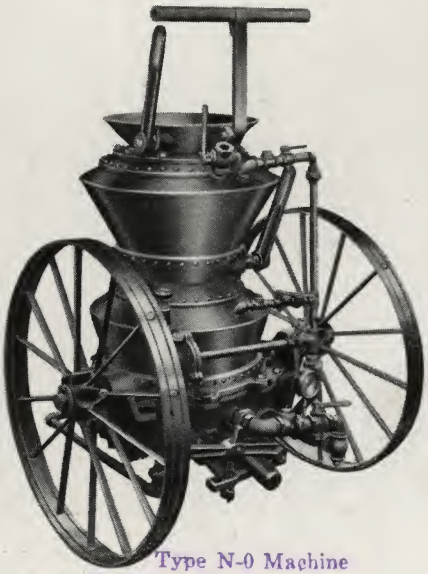
CEMENT GUN CO., Inc.

ALLENTOWN, PENNA.

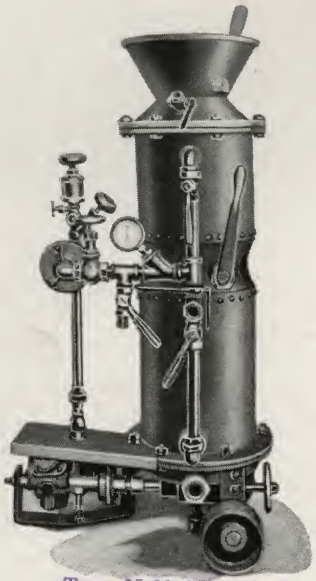
BULLETIN 139-A. MARCH, 1928.

We have other Bulletins dealing with all phases of "Cement-Gun" work. If you do not have them please write at once.

The "Cement-Gun" was intended originally for the application of Portland Cement and sand in building construction but about ten years ago it was tried in an experimental way in placing refractory materials in coke ovens and furnaces. This work proved so satisfactory and showed so many possibilities for work of a similar nature, that it has rapidly spread and the machine and method is now widely used in power plants, steel mills, and manufacturing plants of every description for general maintenance, with refractories, of boilers and other furnaces, soaking pits, ladles, etc., as well as the building of new baffles directly in place.



Type N-0 Machine



Type N-00 Machine

The type N-00 machine requires 60 cu. ft. of actual free air per minute at 25 to 50 pounds pressure dependent on the work to be done. The type N-0 requires 100 cu. ft. at the same pressure.

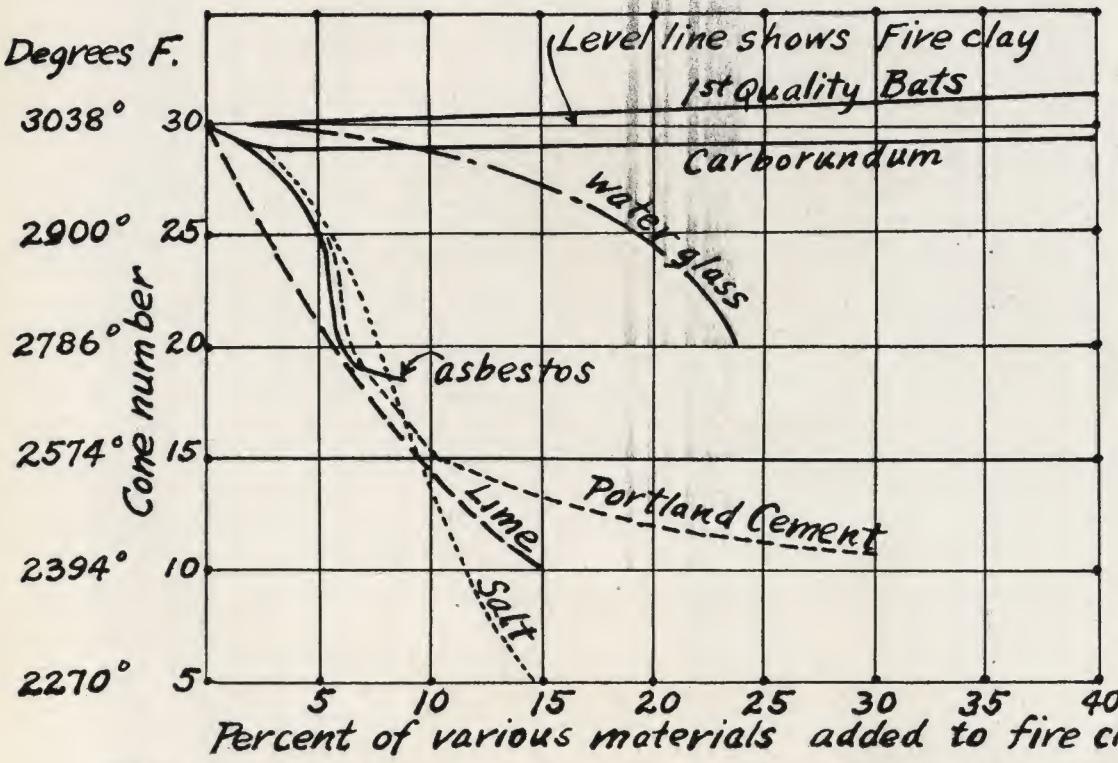
The 'Cement-Gun", due to its method of operation, is entirely different from any of the furnace spraying devices on the market. Its chief advantages are:—

1. Only dry material is used. This passes through the hose to the nozzle where the water is added. The hydration is controlled by the operator and can be changed at will, assuring proper hydration at all times. Additional water (or no water at all) can be used if desired.

2. It is not necessary to stop work to reload the machine; the operation is continuous.

3. On vertical surfaces and bottoms, the material can be placed to any thickness in one coat. On arches and other overhead work the material can be applied in successive coats, each coat ¾" thick.

4. Two or three men can usually handle any repair job.



ANALYSIS OF FIRE CLAY USED IN TEST

IGNITION	11.12
SILICA	56.42
ALUMINA	28.46
FERRIC OXIDE	3.12
LIME	.52
MAGNESIA	.44
ALKALIES	.24
	100.32

Taken from Aug 11, 1920
CHEM. AND METALLURGICAL ENGINEER

TABLE PREPARED BY MELLON INSTITUTE SHOWING EFFECT ON THE FUSING POINT OF FIRE CLAY BY ADDITION OF VARIOUS MATERIALS

5. All the mixtures used contain at least 75% material which is ordinarily wasted. These mixtures when prepared for the "Cement-Gun" cost less than $10.00 per ton.

6. The "Cement-Gun" will place from 1000 to 6000 pounds of dry material per hour, according to the size of machine used.

REBUILDING AND MAINTAINING BOILER FURNACES.

The maintenance of boiler furnaces with the "Cement-Gun" has proved so successful and economical that a large number of plants are equipped with these machines, and numerous boilers are now being operated with greatly reduced maintenance charges and with less "down time" than formerly.

The MATERIALS used vary somewhat in different plants to suit local conditions of quality of brick, design and rating of boiler, length of time between repairs, fuel used, etc. The general base of all mixtures used at the present time is ground fire brick, which is used with approximately 20% of high grade, low shrinkage fireclay. In some plants it is the practice to reduce the amount of fireclay and add from 3% to 5% of soda ash. Other plants use a solution of silicate of soda in hydrating the mixture. The final determination of the mix depends on the individual conditions encountered. However, it is well to remember that an excess of fireclay (more than 20 or 25%), or the use of a low grade clay, will cause cracking.

The materials should be thoroughly mixed dry and screened through a ¼" mesh screen before being placed in the "Cement-Gun". The brick should be ground to pass a screen of ⅛" mesh.

Little or no preparation of the furnace is required. The work may be done as soon as the furnace is cool enough to permit entry of the operator, or at any time thereafter. Loose clinker and ash must be removed and the surfaces blown off with an air blast from the nozzle of the "Cement-Gun", adding a very small amount of water.

METHOD OF APPLICATION.

Shoot the mixture directly over the glaze, filling out all spalled portions and holes. In some cases it may be necessary to apply six inches or more, but usually from three-quarters to two inches is sufficient, as it is more advisable to build up deeply eroded surfaces in several applications, and after an additional period of operation.

On the underside of arches small holes can be filled out completely but for the entire surface do not place more than ¾" thickness in one coat. If a greater thickness is desired a second coat should be applied later.

The furnace can be put back on the line as soon as the repair work is completed. No drying out fire is required unless the furnace is to remain idle for a considerable time.

It is not intended that this coating shall stand up indefinitely as it will gradually erode and melt away as does brick. It is rather the intention to maintain the brick indefinitely by frequent coatings. Whenever the boiler is "down" the work can be inspected and, if necessary, another coat applied. Under ordinary conditions each operation should not require more than one-half to three-quarters of an hour.

A report recently made for the Harbison-Walker Refractories Company by the A. C. Nielson Company, of Chicago, describes the repairs on boilers at the Indiana Electric Corporation plant, Terre Haute, Indiana, where a mixture of "Bond B" fireclay and ground fire brick was used. This is summarized as follows:—

*"*Bond B" and ground fire brick used for furnace repairs at the large central station applied with the "Cement-Gun".*

To side, end and division walls and to face of arch.

Highly resistant to flame, adheres strongly and does not crack.

Two men can apply one ton per hour. Four to six hours required on 1726 H. P. boiler furnaces.

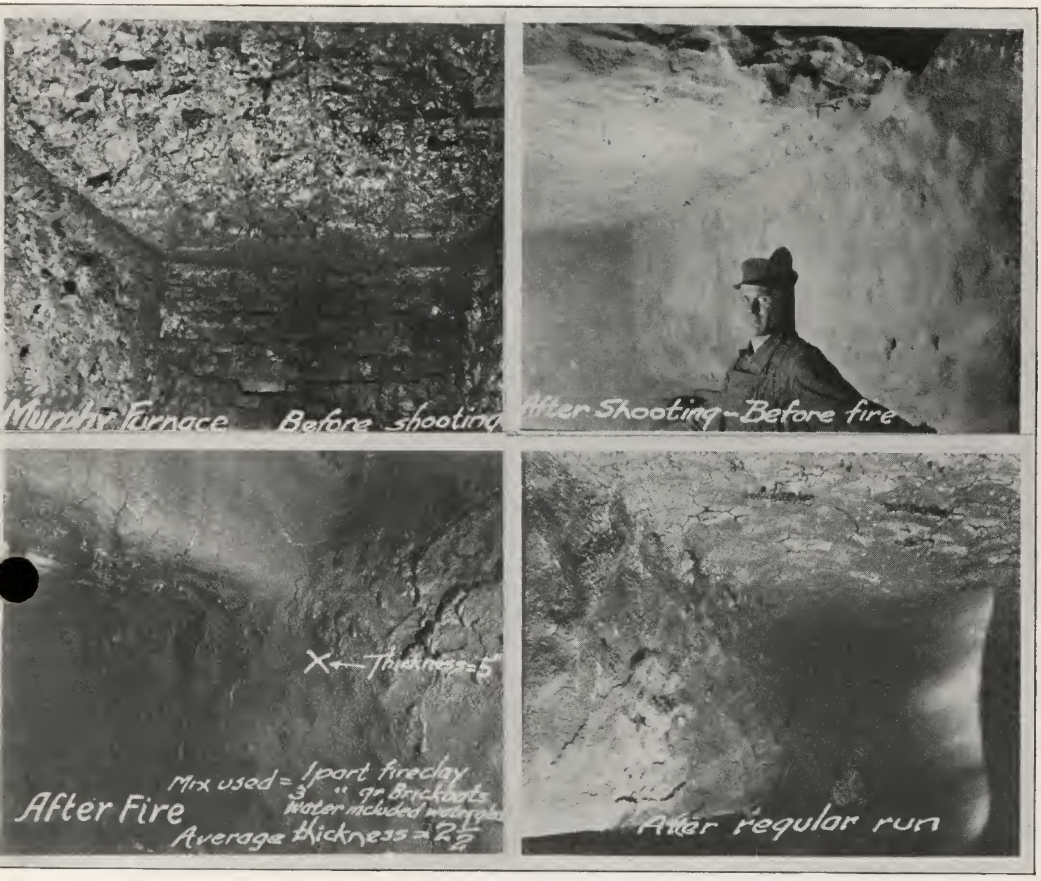
Formerly required ten days for patching.

Reduces down time of boilers by nine days.

Reduces cost of work $2400 a year per boiler.

Increases arch life from 6–8 months to 8–10 months."

The summary of this report is not unusual as the savings indicated, while very appreciable, are not exceptional. Many plants report better results. A very striking illustration of the results obtained and the savings effected in other plants and under different conditions is shown in the reprint on Page 6 of a letter from the Sugar Pine Lumber Company, Pinedale, California.



*"Bond B" as we understand it is a high grade fireclay with very low shrinkage.

SUGAR PINE LUMBER COMPANY

PINEDALE FRESNO SUGAR PINE CALIFORNIA

December 17,1927.

Cement-Gun Company, Inc.
Allentown, Pa.

Gentlemen:-

Your letter dated December 9th,and addressed to Mr.Cannon has been referred to the writer for answer.

Under date of October 26,1926 Mr.Cannon gave you some figures relative to savings effected by use of Cement-Gun in our furnaces,those figures are a conservative estimate of our savings for the past year.

This plant has being in operation since July 1923,therefore,we have had five operating seasons,we still have the origional furnaces in service, we are satiesfied that our furnaces are good for at least one more season, in fact,we will not be at all surprised if we get at least two more seasons operation without rebuilding,perhaps longer.

Considering that our boilers are operated at close to 200% of rating during our operating season we feel that the life of our furnaces are exceptional long,we are entirely satiesfied that the use of the Cement-Gun has made this possible,as a matter of fact,by using the Cement-Gun regularly we can see no reason why our furnaces should not last for several more seasons.

At the present time we shoot each furnace every four weeks and are using a mixture of 2 to 1,we found that with the refractory now used we get much better result using this rather than the 3 to 1 mixture which we used at the time Mr.Cannon wrote you.

We have found that it is exceedingly important that the right hydration is used,at first we had to experiment considerable before we finally discovered where our mistake was made,one reason was that our water supply is carried to the gun under 125 Lbs.pressure,this of course necessitated careful manipulation of control valve at Nozzle.

Yours very truly,

Sugar Pine Lumber Co.

By N.M. Hansen

N.M.Hansen
Chief Engineer.

NMH:b

The figures on savings given in Mr. Cannon's letter of October 26, 1926, and referred to above, showed a saving of over $5,000, for the year. This was an actual cash saving and was in addition to the saving in lost time and the assurance of maximum boiler capacity available at all times.

BAFFLES.

Leaky baffles have been one of the most serious problems that power plant operators have had to contend with. The use of the "Cement-Gun", both for original construction of baffles as well as their maintenance, has largely overcome this trouble and expense. Probably the most extensive use for such repair is at some of the plants of the Commonwealth Edison Company of Chicago where a thin coating is applied over the baffles during inspection periods. At the plant of another large utility corporation the statement has been made that such repair has effected a saving of 1% in the amount of coal consumed. As this plant consumes 1500 tons of coal per day such saving will approximate at least $50.00 per day.

To build a new baffle with the "Cement-Gun" a frame work of light strips is placed between the tubes. To each of these strips has been previously fastened a heavy card-board template fitting the tubes. These strips are introduced "on edge" and subsequently "turned" so that when finally fixed there is presented a surface against which the material from the "Gun" is impelled.

The "shooting" is done with an extended curved nozzle so held that the end of the nozzle is in close proximity to the form. The operator stands either above or below the bank of tubes and with proper lighting (preferably a focusing flashlight) it is easily possible for him to have a clear view of the nozzle and see that the material is placed to proper thickness and lines.

The same material as that used for wall repair is frequently employed in baffles but some operators consider it advisable to use a mixture of asbestos or other somewhat flexible material. The Johns-Manville Company have used their own asbestos cement with great success in building and repairing the baffles at their plant at Manville, N. J. with a "Cement-Gun".

STEEL MILL REPAIRS

REPAIRS TO HOT FURNACES.

One of the most expensive items in any repair job is the time lost by shutting down to make repairs. Many furnaces could operate indefinitely except for the need of frequent or occasional refractory repairs. In recent years the use of the "Cement-Gun" for making such repairs without shutting down has been adopted by several of the steel companies. Repairs which formerly required a shutdown of several days are now made in one or two hours.

The "shooting" under heat is handled by means of an extension nozzle long enough to apply the material to any part of the furnace. This extension simply consists of a piece of ¾" or 1" straight pipe attached to the standard tapered nozzle tip. Lengths of pipe up to 20 ft. are used without difficulty.

An OIL FIRED heat treating furnace at the plant of Allis-Chalmers Company, Milwaukee, Wis. The photograph on the left shows the furnace walls after 11 months continuous service, operating under heats of approximately 3000°F. NOTE THE "CEMENT-GUN" APPLIED MATERIAL STILL IN PLACE.

This photograph at the right shows the same furnace again restored with the "Cement-Gun" using mixture of crushed fire brick and fire clay, permitting its use continued for practically another year.

The "shooting" of the material is done in the same manner as when "shooting" a cold job. The operator, outside the furnace, controls the amount of water used. The only precaution found necessary is to keep the air pressure down to about 20 pounds. If a high pressure is used the wet material packs too densely on the hot walls and spalling may occur due to the development of steam.

Hot repairs may be made on any furnace where the walls and arch are accessible from the doors or other openings. Front walls and the front part of the arch are patched by removing a brick here and there in the back wall. These openings are closed up with the "Cement-Gun" as soon as the work is completed. Door jambs, always troublesome, can be kept in first class condition at all times.

The MIXTURE used in most cases is about the same as used in boiler furnace repairs, with variations as required to suit the conditions encountered. A mixture being used very successfully on various types of heating furnaces for temperatures up to 2500 degrees F. is:

85% Ground Checker Brick passing 1/8" screen.
12% High Grade, Low Shrinkage Fireclay.
3% Soda Ash.

Old checker brick are generally considered preferable because they are more thoroughly and uniformly burned, but if not available, any other fireclay brick-bats may be used. For temperatures above 2500 degrees F., ground chrome brick or chrome ore is added in amounts from 10% to 40%, deducting the same amount from the volume of the brick-bats.

As an example of the success of hot repair work, one of the large steel plants in the Pittsburgh District has nine "Cement-Guns", seven of which are used almost exclusively for hot repairs. This work includes linings and repairs on all of the various types of HEATING FURNACES and SOAKING PITS. At this plant it has been proven that the cost of labor and material in repairs made by the "Cement-Gun" is cheaper than by former methods; that the loss of time has been practically eliminated; and that the life of the furnaces has been increased from 50% to 300%.

A very recent report tells us of the success of a newly tried mixture of 35% Graphite (waste from open hearths), 50% ground fire brick and 15% fireclay, on high temperature furnaces.

Some work has been successfully done in repairing surfaces of silica brick. The main difficulty in the past has been in obtaining a proper refractory material. Recently, however, mixtures with a greater or less percentage of chrome ore have shown marked evidence of this difficulty having been overcome.

A very successful application in connection with Silica brick was made in repairing a gas retort at Brockton, Mass., where excessive shrinkage had caused a rather serious condition.

It is to be borne in mind that the "Cement-Gun" will successfully place material in places and under conditions where no other method of repair would be possible.

LINING LADLES

Similarly, the "Cement-Gun" is also used extensively in the steel plants for the lining of ladles. The general practice in the American plants for basic steel ladles is to "shoot" a thin lining after every heat or every other heat, thereby protecting the brick lining and extending its life to such a degree that ordinarily twice the number of heats can be obtained, and in a number of cases a considerably larger increase. Several plants where ladles are lined with the "Cement-Gun" have reduced the thickness of the brick lining, thereby increasing the capacity of their ladles.

The mixture generally used is approximately:—

80% Ground Brick-bats,
20% Fireclay,

with variations in this mixture to suit the local conditions. The general method of handling the work is to cool the ladle and "shoot" the mixture on the bottom and sides approximately ½" thick, the only precaution being to remove the loose material accumulating in the bottom after the ladle has been "shot". The ladle should then immeddiately be dried out and kept hot until ready for use. In drying out the ladle, it is advantageous to heat the lining almost to the fusing point, care being taken that the drying out process be done not too rapidly.

Many German plants have been very successful in ladle lining apparently largely due to the fact that the newly "shot" ladle is placed under extreme heat for a period of from six to eight hours. As a result it has been found that the lining will last for five or six heats without another "shooting". They also report that they average better than 200 heats per ladle as a result of care taken in the "shooting" and heating of the lining.

One of the large American Plants is at present carrying on experiments in their steel ladles using a method similar to the careful methods of the German plants. At this plant they take a ladle with a new brick lining and use it for twelve (12) heats before the first "shooting", then they "shoot" the ladle after every sixth heat with a lining not less than ½" thick which is very thoroughly dried out. From present indications they will average better than 200 heats per ladle which will show a saving of approximately 7 cents per ton of steel produced.

Several of the steel casting plants report that by doing the shooting carefully and drying out the ladles thoroughly, they do not have to replace a brick lining oftener than once a year, and one plant reports that they renew their brick linings once every two years.

Many plants also use the "Cement-Gun" for lining iron ladles. For such work they usually use one course of brick in the bottom of the ladle and no brick in the sides, shooting the lining approximately 2 inches thick.

The time required to shoot a 100 ton ladle with a lining ½ inch thick is about ten to fifteen minutes. In most plants this work is done by the regular ladle crew so that the only additional expense is approximately $5.00 per ton for the material used, plus the cost of thoroughly drying out the lining.

The "Cement-Gun" is also used to good advantage in the Open Hearth Departments for lining checker chamber walls to protect them and seal against all leakage.

WATER GAS GENERATORS

The lining of these retorts has always been a source of continual care and expense, having generally demanded practically a re-lining after each 1500 or 1600 hours of operation. Linings are now being used of a mixture of ground fire brick and fireclay which have given highly satisfactory results. It is well to bear in mind that the lining placed with the "Cement-Gun" should not exceed three inches in thickness, as the high refractory character of this lining sometimes prevents the proper fusing to the original surface when thicker than 3 inches. In one case a lining 4 inches thick successfully passed through 1600 hours of operation, but broke away from the old surface when the slag was being removed, showing a dried out and un-fused condition next to the old lining. A thinner lining on this same generator subsequently successfully withstood a similar test.

SEALING THE OUTSIDE OF FURNACE WALLS TO STOP AIR LEAKS.

The "Cement-Gun" is also used very extensively for sealing the outside of furnace walls against air infiltration. For this work the usual mixture for "Gunite" (one part Portland cement and three parts sand) is used and the coating is applied to a thickness of approximately one-half inch.

One of the large plants in the Pittsburgh District use this method of sealing their boiler furnace settings and report a very appreciable increase in the capacity of their boilers with the result that they are now operating with fewer boilers on the line. They use a coating ½" thick over both walls and tops and a recent inspection showed them to be in perfect condition with no signs of any cracking.

FOR SANDBLASTING OF BOILER TUBES.

In addition to its use as a machine for placing refractory materials the "Cement-Gun" has proven its very high efficiency as a sand blast machine. One or two large power plants in the country use their machines solely for sand blasting tubes and hand hole plates. It is therefore available for this purpose when not employed in its normal functions.

GENERAL REPAIR AND CONSTRUCTION WORK AROUND THE PLANT.

Although not bearing on its use with refractory materials, engineers of power and steel plants will be interested to know how extensively the "Cement-Gun" is being used with its standard product "Gunite" (a mixture of standard Portland Cement and sand) in the upkeep and maintenance of these plants.

It has been known for several years that a layer of Portland cement when applied in direct contact with a steel surface assures perfect protection against corrosion, and it has been definitely shown that not only does the "Cement-Gun" insure this direct contact but also provides a protective coat of mortar or concrete (called "Gunite") which is stronger and denser than any other sand and cement product yet produced.

Similarly, "Gunite" has proven to be the only method of permanently repairing and protecting concrete and masonry structures of all kinds. Its perfect adhesion to the old surface together with its great density assures positive restoration and resistance to the injurious action of acids and alkalis, or other conditions.

Coal Bunkers.

It has been generally accepted for a great many years that all bunkers be lined with a slab of "Gunite" two inches thick. This layer must be reinforced with a mesh fabric with openings not less than 1½ inches nor more than four inches with cross sectional area in each direction not less than three-tenths of one per cent. of the cross sectional area of the "Gunite" slab. The steel surface must be thoroughly cleaned by sand-blasting, or otherwise, before "shooting" the "Gunite". Some engineers have first used a mastic application over the steel surface but our recommendation is against such practice.

Not only are such linings used in fixed bunkers but also they have proven very successful in bunkers of the parabolic suspended type even though such bunkers are subject to considerable distortion. Very excellent illustrations of this success are the bunkers at the plant of the Pullman Car & Mfg. Corporation, Michigan City, Indiana, or the Ford Motor Company, Detroit, Michigan, where the linings have been in place for over ten years. (See letter next page).

Lining Boiler Breechings.

The protection against corrosion as proven by bunker linings together with the resistance of "Gunite" to heat action (up to 800 degrees F.) and transmission, lead the engineers of the Commonwealth Edison Company to adopt "Gunite" linings for the boiler breechings at the Calumet Station in Chicago. The success of this lining has caused its adoption at Cahokia (St. Louis) and other large plants.

Coal Trestle Protection.

A serious maintenance charge affecting various plants has been due to the rapid breaking down of coal trestles, whether built of steel or concrete. "Gunite", due to its high resistance to acids has been extremely successful in making repairs and curing the condition.

PULLMAN CAR & MANUFACTURING CORPORATION

HASKELL & BARKER PLANT

MICHIGAN CITY, INDIANA
Feb. 14, 1928.

Mr. B. C. Collier, Pres.,
Cement-Gun Co., Inc.,
Allentown, Penna.

Dear Sir:-

Replying to your letter to the Krehbiel Company, dated January 28th, 1928, with reference to the results obtained with the Gunite lining in coal bunkers at this plant.

I am pleased to state that no trouble whatever has been experienced with this lining since its application some 15 years ago. The only developement noted is a very narrow vertical crack through the center, permitting moisture to reach steel work. This was more than likely caused by overheated coal in storage at some time or other.

The size of bunker is 90 ft. long, 18 ft. deep and 24 ft. wide at top, being of elliptical crossection. It would be difficult to give any figures on deformation from this end as no tests in this respect were ever made to my knowledge. However, since the Gunite lining shows no indication of strains due to deformation, would say this was very slight.

Yours very truly,

A. C. Lohse.

ACL-mtw

Master Mechanic.

Condenser Boxes.

The rapid corrosion of condenser boxes in oil distilleries and similar plants has been a source of constant care and maintenance as the steel surfaces are subjected to highly corrosive conditions. "Gunite" has effectually cured this trouble wherever used. A very excellent example was shown in a plant of the Pure Oil Company, at Tulsa, Oklahoma, where the boxes were subjected to extremely severe conditions due to the high alkalinity of the water. The plates were protected with a "Gunite" lining about four or five years ago. A few months since this plant was dismantled for removal to another site and the steel in these tanks was found to be in a state of perfect preservation. It was further found that the "Gunite" lining itself showed no evidence of any attack from the disintegrating agents which so generally rapidly destroy other cement products.

Ash Pits.

Ash pits have been frequently lined with "Gunite". A report from the Engineering Department of the Chicago & Northwestern Railway states that they have found such work more successful than several previously tried linings. A very interesting case of ash pit and air duct lining and repair is at the plant of the Beech Bottom Power Company (American Gas and Electric Company), at Moundsville, W. Va. The steel in the ash pits and surrounding structures at this plant was practically destroyed from corrosion. By using ingenious engineering methods and designs the walls and other portions were rebuilt directly in place and although this work has been in constant use since 1921 a recent examination shows the "Gunite" to be in excellent condition.

Flue Linings.

Around steel and copper refining plants "Gunite" is being extensively used not only for protecting the exterior of flues but frequently for lining and rebuilding old flues which have been practically destroyed. At the Calaveras Copper Company, Copperopolis, California, large flues have been built entirely of "Gunite" over forms. (Vide ENGINEERING & MINING JOURNAL PRESS, April 8, 1922.)

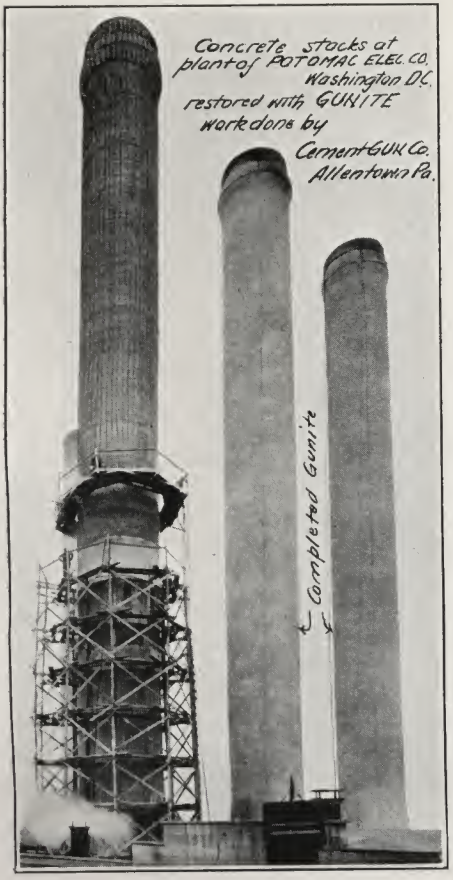
LINING STACKS

A very interesting use of the "Cement Gun" in refractory work is the lining of a steel stack at the plant of the Great Western Power Co., in Oakland, Cal., where, in 1924, a lining consisting of Silocel (diatomaceous earth) and Portland Cement was placed in the heat zone of the stack. We have received very recent reports to the effect that this construction has been very successful, both from the standpoint of insulating qualities as well as permanancy. A similar use of this material is being used by the Donner Steel Co., Buffalo, N. Y., for insulating furnaces.

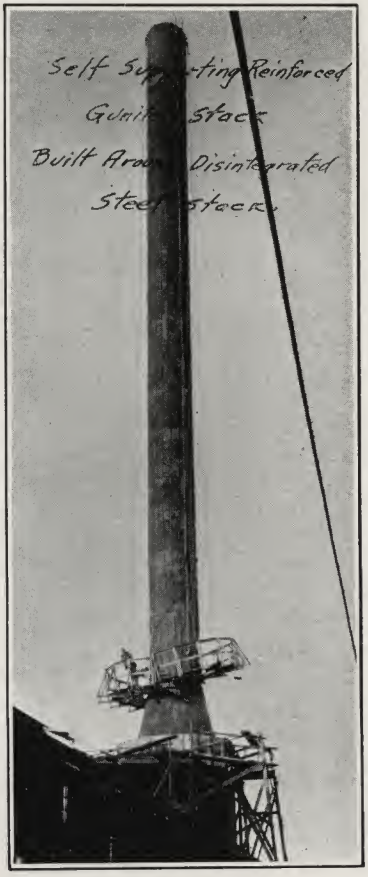
STACKS.

One of the most interesting developments of "Gunite" work has been the replacing of destroyed steel stacks with new reinforced "Gunite" stacks so designed as to be self supporting. The old stack is used merely as a form and generally the new stack is built without putting the old stack out of commission. This method of restoration is more than ten years old and has been used successfully all over the country in a very large number of stacks, some as high as 210 feet.

Due to the disintegrating action of coal gases and acids on concrete a number of concrete stacks throughout the country have within the last few years shown the necessity of extensive repairs. "Gunite" has assured a positive restoration of the stack either for interior or exterior repairs.



Restoring Concrete Stacks,
Potomac Edison Co.,
Washington, D. C., 1926



Building GUNITE stack around old steel stack at American Locomotive Co., Dunkirk, N. Y., 1924

Both of these jobs executed by our Contract Department

The successful use of the "Cement-Gun" in scores of plants throughout the country is ample evidence of the efficiency of this method of maintenance, and we are pleased to submit the following list of representative plants using our machine in refractory and insulating work:-

American Gas & Electric Co., New York City.
Beech Bottom Power Co., Wheeling, W. Va.
Rockford Electric Co., Rockford, Ill.
Indiana & Michigan Electric Co.,South Bend, Indiana.
Indiana General Service Company, Muncie, Indiana.
Scranton Electric Co. Scranton, Pa.
The Ohio Power Company, Philo, Ohio.
Appalachian Power & Light Co., Cabin Creek, W. Va.
West Virginia Water & Electric Co., Charleston W. Va.
Exeter Power Co., Pittston, Pa.

W. S. Barstow & Co., New York City.
Metropolitan Edison Co., Reading, Pa.
" " " Middletown, Pa.
Pennsylvania Edison Company, Easton, Pa.
Broad River Power Company, Parr, S. C.

Commonwealth Edison Company, Chicago, Ill.
(Have machines in three plants).

Detroit Edison Company Detroit, Mich.
(Have machines in two plants).

Public Service Electric Co., Newark, N. J
(Have machines in two plants)

Ohio Public Service Co., Warren, Ohio,
" " " " Melco, Ohio.

Swift & Company, Chicago, Ill.
(Have machines in four plants).

Pure Oil Company, Columbus, Ohio.
(Have machines in two plants).

Consolidated Gas, Electric Light & Power Co Baltimore, Md.

Greenfield Electric Light & Power Co., Greenfield Mass.

Springfield Gas Light Co., Springfield, Mass.

Fisher Body Corporation, Detroit, Michigan.

American Car & Foundry Co., Buffalo, N. Y.

Nichols Copper Co., Laurel Hill, New York.

Rochester Gas & Electric Co.,Rochester,New York

Miller Rubber Company, South Akron, Ohio.

Hammermill Paper Co., Erie, Pa.

Erie Forge & Steel Co., Erie, Pa.

Shenango Furnace Co., Sharpsville, Pa.

American Rolling Mill Co., Ashland, Ky.

Indiana Electric Corp., Terre Haute, Ind.

Drummond Miller Company, Cleveland, Ohio.

Roxana Petroleum Co. (machines in three plants)

National Cash Register Company, Dayton Ohio.

Carnegie Steel Company, Pittsburgh, Penna.
(In six Plants—13 machines)

Jones & Laughlin Steel Co., Pittsburgh, Penna.
(2 plants—four machines).

Duquesne Light Co., Pittsburgh, Penna.

American Sheet & Tin Plate Co., Pittsburgh, Pa.

Houston Lighting & Power Co., Houston, Texas.

El Paso Electric Railway Co., El Paso, Texas.

Spokane Central Heating Co., Spokane, Wash.

The Texas Co., Port Arthur, Texas.

Allis Chalmers Manufacturing Co.,Milwaukee, Wis

Fort Worth Power & Light Co., Fort Worth, Texas.

Potomac Edison Co., Hagerstown, Md.

Pittsburgh Plate Glass Co., Pittsburgh, Pa.

Studebaker Corporation, South Bend, Ind.

Ingersoll-Rand Co., Phillipsburg, N. j.

Memphis Power & Light Co., Memphis, Tenn.

Washington Gas Light Co., Washington, D. C.

Crossett Lumber Co., Crossett, Ark.

Cohoes Power & Light Co., Cohoes, N. Y.

Sugar Pine Lumber Co., Pinedale, Calif.

Williams Cypress Co., Patterson, La.

Brooklyn Edison Co., Brooklyn, N. Y.

Goodyear Tire & Rubber Co., Akron, Ohio.

Maxwell Motor Corporation, New Castle, Ind.

Nekoosa Edwards Paper Company, Port Edwards, Wis.

New Orleans Public Service Company, New Orleans, La.

Iowa City Light & Power Co., Iowa City, Iowa.

Consumers Power Company, St. Paul, Minn.

Public Service Company of Illinois, Joliet, Ill.

Armour & Company, Chicago, Ill.

Dodge Brothers, Detroit, Mich.

A. M. Byers Co., Girard, Ohio.

Allegheny Steel Co., Breckenridge, Pa.

American Steel Foundries.

Wheeling Mold & Foundry, Wheeling, W. Va.

Wheeling Steel Co., Steubensville, Ohio.

Bethlehem Steel Co., Johnstown, Pa.

CEMENT-GUN
TRADE MARK

Instructions for the Care and Operation of the Type "N" "Cement-Gun"

(Trade Mark Registered)

The "Cement-Gun" is a machine and as a machine requires careful and intelligent care, and the instructions contained herein should be strictly followed.

When setting up the machine the most economical results are obtained by placing the "Gun" as near to the surface to be covered as is practicable, due consideration being given to location of material, etc. The air compressor may be located at the most convenient point and air carried to the "Gun" through the air line. Care should be taken, however, not to have the compressor too close to the "Gun" and mixing, so that the dust will not get into the moving parts of same.

To Start "Cement-Gun"

The hose for supplying air from the main feed line to the "Cement-Gun" is connected at the union inlet "A". All cocks controlling air on the "Gun" should be closed before admitting air to the machine. Hose for discharging the mixed sand and cement is attached to end of outlet valve No. 912.

Chambers 926 and 934 are then filled to a point which will just permit upper cone valve No. 928 to close, with dry material which has previously been thoroughly mixed in the desired proportions and screened against all particles above ¼ inch. Cone valve 928 is then closed by means of upper handle 933 and held tightly in place. *Cock "C" in the air supply line is opened until the air gauge shows a pressure of from 10 to 15 pounds, this pressure being subsequently increased as explained hereafter.*

In the meantime the nozzleman at the outlet end of the hose must test the water supply control valve to determine whether there is sufficient pressure (water pressure to be effective should be at least 20 pounds higher than the air in "Gun") and to see that only enough water will be admitted through the small holes in the nozzle ring into the dry mixture to cause it to stick to the surface to be coated.

If insufficient water is supplied the placed material will appear dry while if too much water is admitted the material will run off or slip. *The proper amount of water is being admitted when the surface of the mixture as applied to the wall shows a glossy color or finish and begins to build up without appearance of dry spots.*

Now the valve "E" in the air supply line to air motor (939) *is opened sufficiently to allow the motor to operate at a slow speed. Cock "C" should now be opened a little more so that air pressure on the gauge will show 25 to 40 pounds, or even higher if necessary for proper operation.*

The "Gun" being now in operation the speed of the air motor should be increased until the desired capacity is had at the nozzle and the water supply at the nozzle so regulated until the material issues from the nozzle without dust and at the same time without an excess of water appearing on the work. Remember that the amount of water to be added is always under visual control and is regulated by the valve in the nozzleman's hand.

To Refill the Machine

To keep a constant flow of material running through the hose it is necessary that the machine be refilled every two or three minutes. It is, therefore, the duty of the "Gun" operator to try to close lower cone valve No. 928. (Do not work this handle too much as it will have a tendency to pack the material in the lower hopper.) When he is able to do this, it means that upper chamber No. 934 is empty. Lower cone valve No. 928 should then be shaken vigorously by means of lower handle No. 933 to remove all loose particles of sand and cement from the cone, and insure a clean seat against the rubber gasket. The exhaust valve at the top of chamber No. 934 is then opened while lower handle No. 933 is being held firmly downward. As soon as the air has been exhausted from this chamber, upper cone valve No. 928 will drop, thus permitting the upper chamber to open and be refilled. If the air in No. 934 does not exhaust quickly it is an indication that lower cone valve No. 928 has not been properly seated, which results in the nozzleman having trouble due to lack of pressure in the lower chamber caused by the air escaping around the lower cone valve. This means that either the valve or gasket is not clean or that the gasket is worn. An excellent means of making sure each time that this valve is properly seated is to open the exhaust valve at the top of the upper chamber to its full capacity for an instant, and then close it. If lower handle No. 933 is fast, that is cannot be lifted upward by the hand, it means that the lower cone valve is caught by the air pressure underneath and that the exhaust may be safely opened, thus permitting the escape of all the compressed air in the upper chamber, allowing same to be opened and be refilled. After upper cone valve 928 drops close exhaust at once.

When the upper chamber has been refilled to within a few inches of the top, the upper cone valve is then shaken free from any cement or sand which may be clinging around the edges of the cone, and is held firmly in place against the rubber gasket while valve "B" is gradually opened. This permits entrance of the air into the upper chamber

and when the pressure has become equal to that in the lower chamber the lower cone valve will automatically drop, due to the weight of the material on top of it, thus allowing the material to flow into the lower chamber after which valve "B" should be closed.

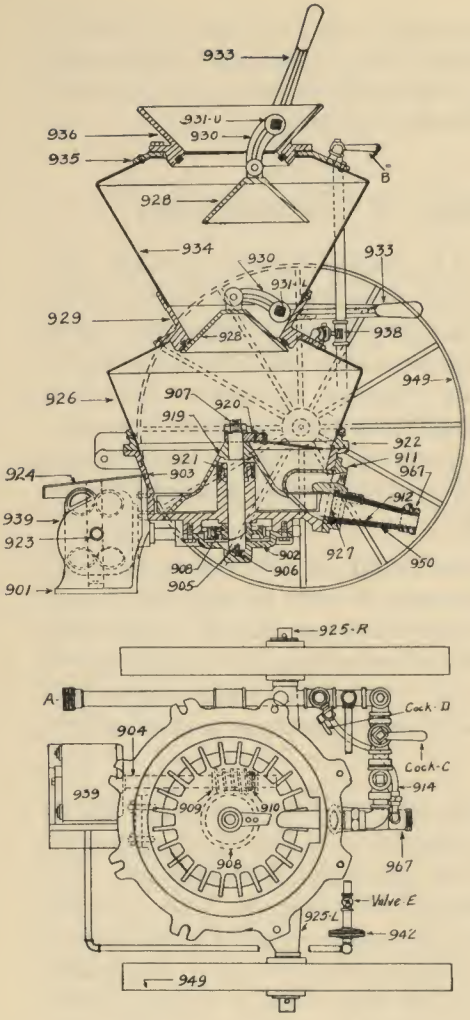
To Shut Off Operation of "Cement-Gun"

First, shut off the air feed to the motor by closing valve "E", then after about thirty seconds, which should be sufficient time for the hose to be cleaned thoroughly, open the exhaust valve at the top of the upper chamber and at the same time shut off cock "C." *If cock "C" is closed before the exhaust valve is opened, the pressure remaining in the "Gun" will force a wad of material into the outlet valve, thus causing it to clog when the machine is started the next time.* When closing down, the lower cone valve should always be open, since there is no exhaust valve in the lower chamber.

When the "Gun" is operated by means of compressed air coming a considerable distance, or on rainy days, it is not unusual that the air is very full of moisture, and when such is the case trouble is sometimes encountered at outlet valve No. 912 or in the hose due to the water in the air causing the cement to set up. The outlet valve is cleared of obstructions by removing the hose at the connection and cleaning it out.

When the "Gun" is shut down for a half hour or more, and at the end of each day's work, the material hose should be connected to connection No. 938 and blown out thoroughly with clean air. This will prevent any trouble with clogged hose when the "Gun" is again put in operation. If the hose should become clogged with material it may often be removed by uncoupling at the outlet valve, re-coupling it to the special valve 938 thus allowing the passage of a larger volume of air than through the by-pass. If it cannot be blown out in this manner, then it will be necessary to take a hammer or piece of pipe and pound the clogged portion until it has become loosened. This clogged portion may be found by feeling along the hose. The pounding should then begin at the end of this hard portion, the loosened material being shaken downward through the hose as fast as broken loose, in this manner the hose may be quickly cleared. Air pressure should be kept in the hose while cleaning out clogged portion.

The only effective remedy against damp air is the placing of an air dryer in the line although sometimes dampness will be reduced by using a receiver near the "Gun." To efficiently operate the "Cement-Gun" it is necessary that comparatively dry air be furnished, and we recommend the Traylor-Dewey Air Dryer which will effectively remove most of the moisture.



LEGEND

901 - FOOT
902 - WORM GEAR CASE
903 - BASE
904 - WORM SHAFT
905 - UPPER THRUST BUTTON
906 - LOWER THRUST BUTTON
907 - FEED WHEEL SHAFT
908 - WORM GEAR
909 - WORM
910 - WORM THRUST BEARING
911 - OUTLET VALVE BODY
912 - OUTLET VALVE
913 - OUTLET VALVE BODY LINER
914 - OUTLET VALVE BY-PASS
919 - FEED WHEEL
920 - AGITATOR
921 - FEED WHEEL SHAFT PACKING GLAND
922 - LOWER TANK FLANGE
923 - AIR MOTOR SUPPORT
924 - AIR MOTOR SHIELD
925 - R - RIGHT TRUNNION
925 - L - LEFT TRUNNION
926 - LOWER TANK
927 - OUTLET VALVE RING
928 - CONE VALVE
929 - LOWER CONE VALVE SECTION
930 - CONE VALVE ARM
931 - L - LOWER CONE VALVE SHAFT
931 - U - UPPER CONE VALVE SHAFT
933 - CONE VALVE LEVER
934 - UPPER TANK
935 - UPPER TANK FLANGE
936 - UPPER CONE VALVE SECTION
938 - BLOW OUT CONNECTION
939 - AIR MOTOR
942 - AIR MOTOR SCREEN
949 - WHEEL
950 - FUNNEL FLANGE
967 - GUN HOSE COUPLING

NOTE - WHEN ORDERING PARTS MENTION NUMBER AND TYPE OF YOUR MACHINE.

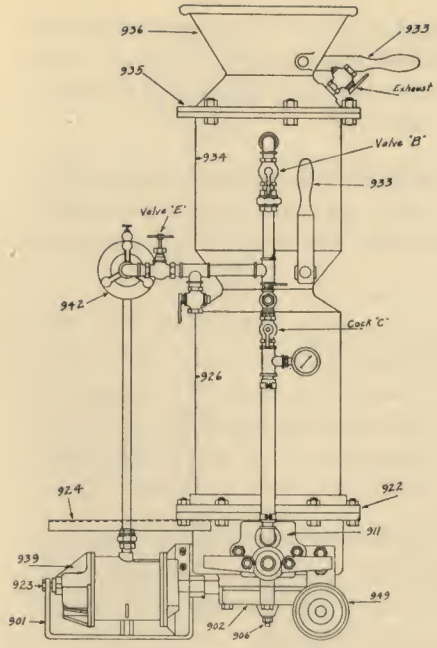
TYPE "N-0" "N-1" "N-2"

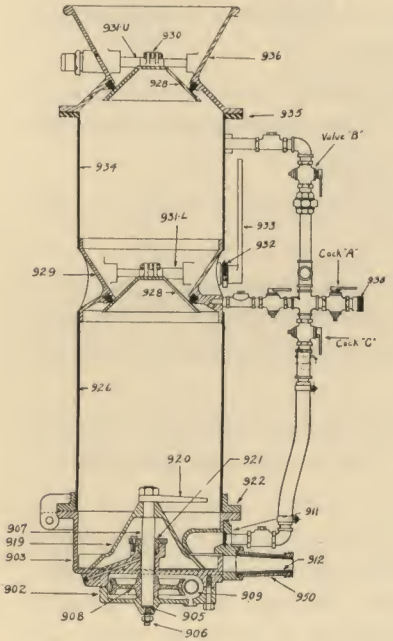
CEMENT GUN COMPANY INC.

ALLENTOWN, PA.

The crew required for the operation of the "Cement-Gun" is dependent on the accessibility of the work and the progress desired, as well as upon whether the cost of labor would demand the use of mechanical mixing of the dry material. Usually the crew consists of a nozzleman, a gunman, and three laborers for hand mixing.

The best conditions for operation are through the use of about 100 feet of material hose, although excellent results have been obtained when 500 or 600 feet of hose were used, the air pressure being increased accordingly. The nozzleman should direct the flow of material as nearly at right angles to the surface as possible, holding the nozzle about 3 to 5 feet from the surface.





LEGEND

901 - FOOT
902 - WORM GEAR CASE
903 - BASE
905 - UPPER THRUST BUTTON
906 - LOWER THRUST BUTTON
907 - FEED WHEEL SHAFT
908 - WORM GEAR
909 - WORM
911 - OUTLET VALVE BODY
912 - OUTLET VALVE
919 - FEED WHEEL
920 - AGITATOR
921 - FEED WHEEL SHAFT PACKING GLAND
922 - LOWER TANK FLANGE
923 - AIR MOTOR SUPPORT
924 - AIR MOTOR SHIELD
926 - LOWER TANK
928 - CONE VALVE
929 - LOWER CONE VALVE SECTION
930 - CONE VALVE ARM
931-L - LOWER CONE VALVE SHAFT
931-U - UPPER CONE VALVE SHAFT
932 - PACKING GLAND FOR SHAFT 931-L
933 - CONE VALVE LEVER
934 - UPPER TANK
935 - UPPER TANK FLANGE
936 - UPPER CONE VALVE SECTION
939 - AIR MOTOR
942 - AIR MOTOR SCREEN
949 - WHEEL
950 - FUNNEL FLANGE
938 - BLOW-OUT CONNECTION

NOTE:- WHEN ORDERING REPAIR PARTS MENTION THE NUMBER AND TYPE OF YOUR MACHINE

TYPE "N-00"

CEMENT GUN COMPANY INC.

ALLENTOWN, PA.

Care of the "Cement-Gun"

Keep all kinks out of the hose.

All grease cups should be filled and given several turns daily. Air motor oiler should feed about five drops per minute.

The interior of the "Gun" should be kept clean, especially the two cone valves No. 928 and the rubber gaskets against which cone valves seat. This is important, as otherwise the valves will not seat properly.

The entire interior of the "Gun" should be occasionally thoroughly cleaned. This can easily be done by removing bolts and studs between Nos. 922 and 903 and opening the "Gun" on hinges. This permits access to all parts.

At the end of each day's operation, outlet valve body No. 911 should be removed and liner No. 913 and rubber outlet valve No. 912 thoroughly cleaned. Pockets of feed-wheel No. 919 should be scraped clean with a scraper or wide-chisel, wheel being slowly revolved and air admitted to the chamber to thoroughly blow out all particles. Space under feed-wheel should be blown out well with small hose.

At least once a month packing around feed-wheel shaft should be renewed with a good grade of soft graphite packing. This should be done carefully, as a leak at this point will allow material to be forced into the gear case and cut the worm and gear.

Feed-wheel No. 919 should be removed frequently to thoroughly clean off material which adheres to underside.

The screen in air motor supply line should be in place and should occasionally be inspected and cleaned. This screen is important, as it prevents any dust from entering the air motor.

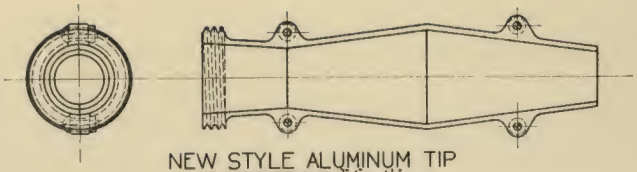
Inspect Worm Gear Case No. 902 occasionally. Motor should also be taken down and cleaned frequently.

The sand used should not be bone dry nor should it be very wet. Very wet sand feeds slowly and tends to clog up the hose and outlet. A normal bank content of from 4% to 8% moisture is about the proper amount.

For ordinary work, the material, both cement and sand, should be screened through a ⅜-inch screen. For a very uniform finish a finer mesh screen should be used.

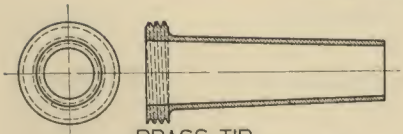
The best results for general work will be obtained by using from 25 to 45 pounds air pressure, but for a first coat or rough heavy work where large capacity is desired, a pressure of from 50 to 60 pounds may be used. For high lifts or long lengths of hose, pressures up to 75 pounds may be used. An insufficient quantity of compressed air is a serious hindrance to good operation.

And remember the "Cement-Gun" has proven to be a very satisfactory sand blast machine.

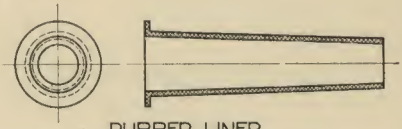


NEW STYLE ALUMINUM TIP
THREE SIZES- $\frac{3}{4}$", 1" AND 1$\frac{1}{2}$".

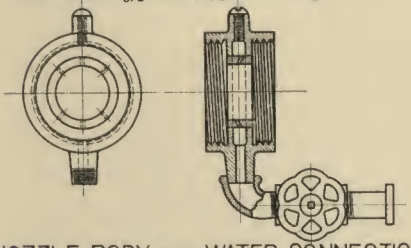
NEW STYLE RUBBER LINER
THREE SIZES- $\frac{3}{4}$", 1" AND 1$\frac{1}{2}$".



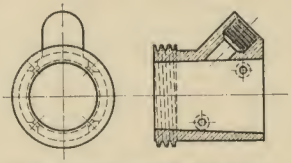
BRASS TIP
FOUR SIZES- $\frac{3}{8}$", $\frac{1}{2}$" SPECIAL, $\frac{1}{2}$" SHORT AND $\frac{5}{8}$".



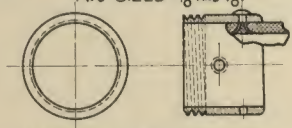
RUBBER LINER
FOUR SIZES- $\frac{3}{8}$", $\frac{1}{2}$" SPECIAL, $\frac{1}{2}$" SHORT AND $\frac{5}{8}$"



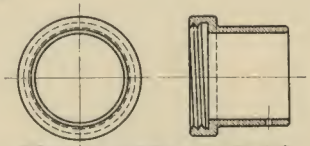
NOZZLE BODY WITH WATER CONNECTION
TWO SIZES- 1" AND 1$\frac{3}{8}$".



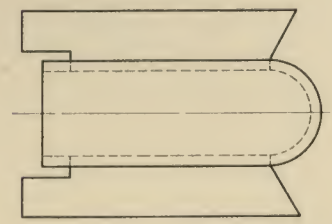
GUN HOSE CONNECTION
THREE SIZES- 1", 1$\frac{1}{4}$" AND 1$\frac{3}{8}$"



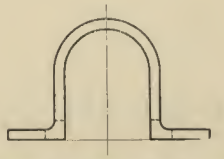
MALE HOSE COUPLING
TWO SIZES- 1$\frac{1}{8}$" AND 1$\frac{3}{8}$".



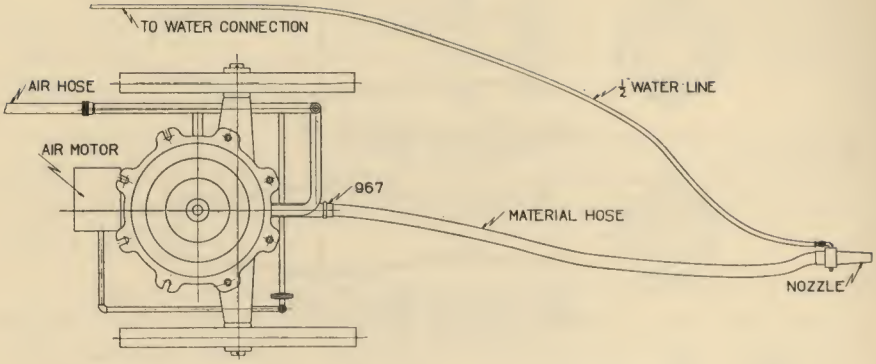
FEMALE HOSE COUPLING
TWO SIZES- 1$\frac{1}{8}$" AND 1$\frac{3}{8}$".



HOOD



This hood is not ordinarily used, except when necessary to restrict the amount of materials. It is used largely in making refractory repairs, and is placed over the goose neck casting No. 911.



Standard Equipment Accompanying Each Machine

N-00

50′ ¾″ material hose, coupled
50′ ¾″ air hose, coupled
50′ ½″ water hose, coupled
1 Nozzle complete with ⅜″ and ⅝″ tips
1 extra nozzle body
6 ⅜″ Liners
6 ⅝″ Liners
2 No. 792 Gaskets
1 Brass outlet valve
1 Rubber outlet valve
1 ¾″ blow-off connection

N-0

50′ 1″ material hose, coupled
50′ ¾″ air hose, coupled
50′ ½″ water hose, coupled
1 Nozzle complete with ¾″ aluminum tip
1 Extra nozzle body (regular)
1 ½″ short tip
6 ¾″ special long liners
6 ½″ short liners
2 No. 791 Gaskets
1 1″ outlet valve
1 Hood

N-1

50′ 1¼″ material hose, coupled
50′ 1¼″ air hose, coupled
50′ ½″ water hose, coupled
1 1⅜″ Nozzle complete with 1″ aluminum tip, ¾″ aluminum tip and ½″ special tip
1 Extra nozzle body
6 ¾″ Special long liners
6 1″ Special long liners
6 ½″ Special liners
2 No. 62 Gaskets
1 1¼″ outlet valve
1 Hood

N-2

50′ 1⅜″ material hose, coupled
50′ 1½″ air hose, coupled
50′ ½″ water hose, coupled
1 1⅜″ nozzle complete with 1¼″ aluminum tip, 1″ aluminum tip and ¾″ aluminum tip
1 Extra nozzle body
6 ¾″ special long liners
6 1″ special long liners
6 1¼″ special long liners
2 No. 62 Gaskets
1 1⅜″ outlet valve
1 Hood

SHIPPING WEIGHTS

(CRATED FOR DOMESTIC SHIPMENT)

N-00	N-0	N-1	N-2
435 lbs.	960 lbs.	1450 lbs.	1550 lbs.

CEMENT-GUN COMPANY, Inc.

Allentown, Pennsylvania

Design and Construction of a Rectangular Suspended Gunite Flume

Severe Conditions of Construction and Operation Determine Both Type of Conduit and Methods of Work. Cost Data Given.

By W. A. KUNIGK
Superintendent of Water Works, Tacoma, Wash.

Reprinted from Waterworks Issue of Engineering and Contracting of Jan. 10th, 1923

The city water department of Tacoma put in service during last May, at the Green River crossing of the gravity water system, a rectangular flume of gunite.

Purpose of Flume.—The gunite flume replaces a wooden flume across the Green River bridge, a 250-ft. riveted Baltimore truss, and an extension of the flume off the bridge for an additional distance of 200 ft. At the upstream end the flume connects with a concrete chamber pier within which the water rises to the elevation of the hydraulic gradient. Thence the water is conveyed across the bridge and through the remainder of the gunite flume with a free board of approximately 8 in. At the down stream end the flume connects with a 60-in. diameter continuous wood stave pipe. On account of this connection the last 33 ft. of flume had to be built with a reinforced top tapering from rectangular to circular section.

Design.—The cross-section of the flume on the bridge is 5 ft. wide by 4 ft. 3 in. deep. The flume hangs from 18 in. I-beams 12 ft. 6 in. on centers across the bridge. At each girder the flume is suspended by four U-bolts made up of ⅞ in. round rods. The threaded ends of the U-bolts pass upward through the flanges of short 6 in. 23-.8 lb. H-beams placed across the main supporting girders and fastened thereto by small lug bolts. The flume proper is connected to the U-bolts by hanger rods made up of ¾ in. round rods cast into the side walls of the flume. It will be noticed that this construction detail will, within certain limits, permit of a lesser rate of expansion or contraction in the flume than that which is simultaneously affecting the steel bridge—a condition that arises when the flume is full of water and a sudden change of temperature occurs.

The side walls are made 3 in. thick with 6 in. by 7 in. coping beams. These side walls act as continuous beams suspended, as described, along the full length of the bridge, carrying the dead load of the flume plus the weight of the water. The stresses due to this beam action are very low. However, it was not considered desirable for practical reasons, to use lighter slabs. The lateral water pressure is taken care of by designing the side walls as slabs freely supported, at the lower end anchored into the flume bottom and at the upper end tied into the coping beams which are prevented from spreading by 3 in. by 6 in. concrete cross ties placed at intervals of 6 ft. along the flume. The bottom slab of the flume is made 3½ in. thick, designed as a slab freely suspended from the side walls. Here the stresses in the gunite are 790 lb. per square inch and in the steel 15,300 lb. per square inch.

At the upstream end of the flume, which corresponds to the anchor end of the bridge, all horizontal reinforcing bars are imbedded and grouted into the drill holes in the concrete of the chamber pier. At the roller or expansion end of the bridge a large copper expansion joint is provided, made up of 3/32 in. by 12 in. copper plate. In order that the effectiveness of this joint might not be impaired by the accumulation of silt and sand it was filled with oakum and a soft asphaltic roofing compound called "Tokoseal."

Off the bridge the width of the flume is increased to 6 ft. 6 in. continuing to a point near the end, where the rectangular section gradually is drawn into a 60 in. diameter circular section. The section of the flume off the bridge is designed in a similar manner as the flume on the bridge, the only difference being that here the flume is supported on a concrete trestle with bents spaced approximately 12 ft. centers. Expansion joints made up of 3/32 in. by 6 in. copper plate are here provided at every other support. These joints were filled with strips of "Elastite" ¼-in. thick.

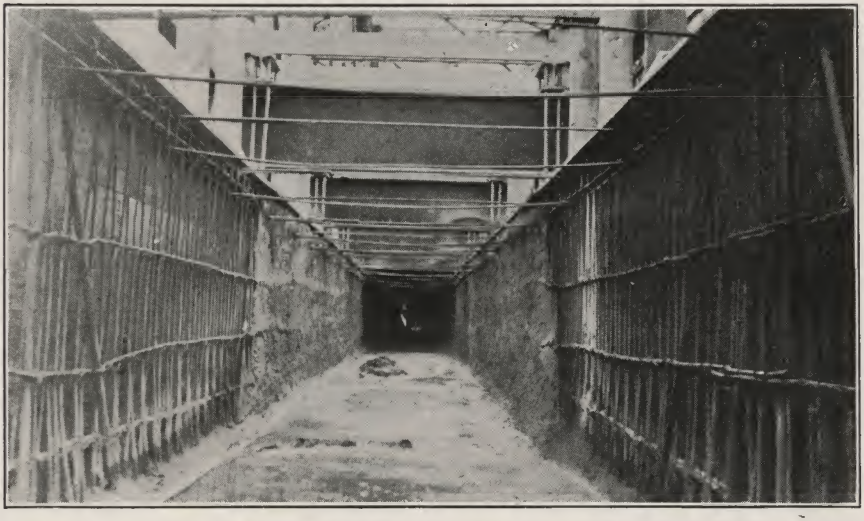
Gunite Flume at Green River Crossing of Tacoma Gravity System

Construction Plant and Methods.—The construction plant consisted of the following equipment: 1 Traylor gasoline-driven compressor of approximately 300 cu. ft. capacity; 1 N-2 cement gun; 1 home-made sand dryer; 1 ¼-in. mesh screen and 1 4 cu. ft. gasoline-driven batch mixer.

On account of the fact that the old flume had to be maintained in service until the new flume was ready for use with very little clearance between the new and the old structure, it was necessary to arrange the work in such a manner that guniting could be done from the inside of the forms. The concrete trestle was first constructed up to the under side of the gunite work. Then the outer form of the flume was built, suspended from the main girders on the bridge, and off the bridge supported on ordinary false work resting on the ground. After the inside of the forms had been painted

with Standard Oil Co.'s "Form Oil" the reinforcing steel, expansion joints and suspenders on the bridge were put in place in their order. The writer wishes here to call particular attention to the necessity of oiling forms where they are to be used in connection with gunite work, as otherwise, on account of the close adhesion of gunite to wood, considerable trouble may be experienced in stripping forms.

The guniting work was then started by shooting the bottom slab first in one layer. The sides were then shot in about three applications of 1-in. thickness each in order to avoid the sagging of the gunite during the finishing. The whole inside of the flume was first floated and then troweled with a steel trowel, presenting a very smooth finish. Practically all guniting operations had to be carried on under canvas cover on account of rain, snow and high winds that prevailed during the greater part of the construction period. A number of times oil stoves had to be placed inside the flume to prevent freezing of the green gunite. Other facts that contributed to

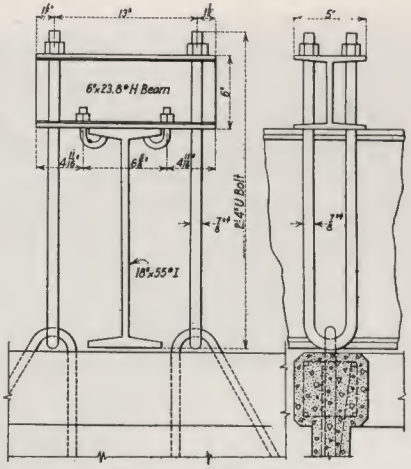


Inside of Flume on Bridge, Bottom Completed; Sidewalls Partly Completed

the out-of-the-ordinary expenses of this work were the inaccessibility of the site; trouble in hauling the men to and from work; the expense of paying for main line train charges every time that a car of material was unloaded; and the continuous annoyance of a badly leaking flume immediately alongside of the new work. The cross ties at the top of the flume were made of poured 1:3 cement mortar. All concrete used was of 1:2:4 mix, and all gunite was made of 1:3 cement and sand, respectively, measured in loose volume. The sand used was a 1:1 mixture of fine clean and sharp plaster and concrete sand with the voids in this combination running less then 30 per cent.

Testing of Flume and Bridge.—In view of the cold weather prevailing during construction, the last gunite shot was left 30 days to cure before the forms were stripped. Adjustment for equal stress on the hanger rods

on the bridge was then made. This proved a delicate operation. Before the forms were stripped the equalizing of the stress on the different hangers was accomplished by taking up on the nuts above the supporting cross beams and by sounding the rods with a hammer until the sound of all rods was pitched to the same key. A perfect adjustment was secured in this way. A wooden bulkhead was then placed in the bell end of the flume, and the water was gradually admitted through a small pipe, taking several hours for the filling operation. Before filling of the flume was started, levels were taken across the 250-ft. span showing a camber of .15 of a foot at the center panel. This camber was gradually reduced during filling to about .03 of a foot when the flume was full without the gunite showing the slightest sign of distress due to this deflection. However, when at the beginning of the filling operation the depth of the water in the flume had been brought to about 6 or 8 in., some 10 or 12 transverse hair cracks developed in the bottom slab, about half of them on the bridge and the other half in the flume off the bridge. These cracks were so fine that they were barely



Detail of Hanger

visible to the naked eye, and except for the few beads of water on the under side of the flume bottom, they no doubt would have been overlooked. When the flume was full all cracks had disappeared and dried up, indicating that they were temperature checks only, caused by the cold water in contact with the bottom.

Precautions Taken to Guard Flume Against Action of Chlorine Gas on the Inside and Effect of Weather on the Outside.—In order to provide additional protection against the action of chlorine gas, the flume was dried out after the test and the whole of the inside was given two coats of paraffine wax applied hot. On the outside the flume was given two coats of concrete paint in order to prevent rust spots from showing on the face of the gunite wherever the reinforcing steel had come too close to the forms. It was also desirable to harmonize the color of the flume with that of other structures in that vicinity.

Cost Data.—The appropriation providing for the work was $11,000 and the total cost of the work was $10,347.94, made up of the following items:

Excavation and backfilling	$308.50
Concrete trestle and foundations (labor and material)	330.00
Re-laying about 60 ft. of 60 in. diameter wood stave pipe and making connections to gunite flume	210.55
Closing chamber pier outlet of old flume	6.62
Dismantling old flume, reclaiming lumber and building walkway across bridge	370.77
450 lin. ft. of gunite flume complete, at $20.15 per ft.	9,067.50
Total cost	$10,374.94

The itemized cost of the flume per lineal foot was as follows:

	per lin. ft.
Forms, form oil, nails for new flume, as well as blocking and shoring for old flume, including all labor	$4.00
Reinforcing and structural steel—61lb. (material only)	3.62
Cutting, bending and placing re-inforcing steel and placing and adjusting structural steel	1.87
Copper expansion joints (labor and material)	.6
Cement	2.13
Sand	.84
Gunite—labor of placing	2.23
Stripping forms	.22
Painting 2 coats paraffine wax inside and 2 coats concrete paint outside (labor and material)	.93
Wooden cover with 3-ply roofing paper (labor and material)	.58
Miscellaneous items such as gasoline, oil, hardware, truck hire, freight on equipment and main line stop charges, etc.	1.81
Superintendence, engineering and testing	1.32
Total cost per lineal foot	$20.15

In connection with the comparatively high cost of the form work, it must be borne in mind that about one-half of the total length of the forms had to be suspended from the bridge and the other half had to be supported on sloping ground that was continuously being undermined by leakage from the old flume.

The prices paid for material delivered at the site were as follows:

Cement, per bbl.	$ 3.62
Sand, per cu. yd.	2.50
Gravel, per cu. yd.	2.81
Lumber, per M ft. B. M.	13.60
Reinforcing steel (corrugated 3-8 in., round), per cwt.	5.93

The wages paid for labor and superintendence were as follows:

Construction engineer, per month	$175.00
Sub-foreman per day	5.50
Carpenter foreman, per day	8.00
Carpenters per day	7.00
Cement finishers, per day	8.50
Cement gun nozzle operator, per day	7.00
Cement gun operator, per day	4.75
Laborers, per day	4.75
Compressor operator, per day	5.50

The labor cost of the cement gun organization was as follows:

1 compressor operator at $5.50 per day	$ 5.50
1 cement gun nozzle operator at $7.00 per day	7.00
1 cement gun nozzle operator helper at $4.75 per day	4.75
1 cement gun operator at $4.75 per day	4.75
1 cement gun loader at $4.75 per day	4.75
2 cement finishers at $8.50 per day	17.00
4 laborers, drying, mixing and screening material, at $4.75 per day	19.00
Total cost of cement gun crew per 8-hour day	$62.75

This crew would place up to 7 cu. yd. of gunite per day. However, the average run per day was approximately 5.31 cu. yd. The actual quantities of material used per 1 cu. yd. of 1:3 gunite in place were 3.12 bbl. of cement and 1.78 cu. yd. of sand, making the cost of the material at the aforementioned prices, $15.68. The labor cost per cubic yard of placing the gunite was $11.81. Total cost of gunite in place, $27.49.

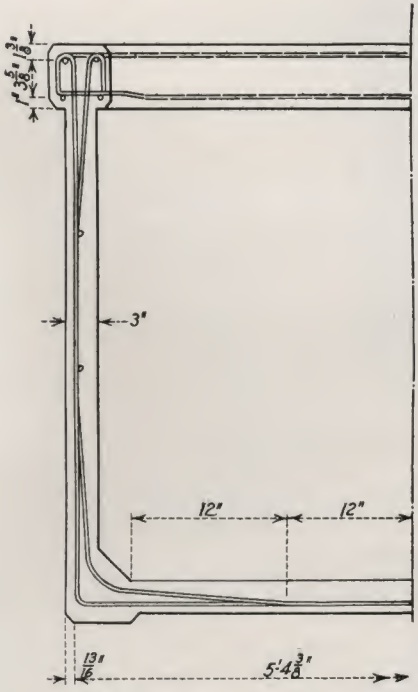
This cost of gunite is higher than it would be under more favorable conditions; for instance, on a job of reservoir lining involving some 26,000 sq. ft., which the writer recently completed, conditions were more favorable and with practically the same equipment and organization, a 2-in. layer of 1:3 gunite was placed with a steel troweled surface at a total cost of labor and material (not including reinforcing) of 12.38 cts. per square foot, or $20.06 per cubic yard. For depreciation of plant there should be added about $1.07 per cubic yard of gunite in place, which represents a depreciation of 3 per cent per month figured on a $7,200 plant investment.

Comment and Conclusions.—Work of this nature can be carried out to considerably better advantage and at greatly reduced costs when weather and working conditions are more favorable, as is apparent from the figures quoted. However, the writer feels well satisfied with the results obtained and a number of engineers who viewed the flume during construction and after completion regarded the work a success in every way. Nevertheless, there are certain features in connection with the design and construction of this flume that the writer wishes to call particular attention to for the benefit of engineers who have to design and construct gunite work. For instance, the coping section along the top of the sides of the flume would have been considerably easier to shoot if all sharp corners had been avoided by a slight gradual enlargement of the slab near the top which would have served just as well from a structural standpoint.

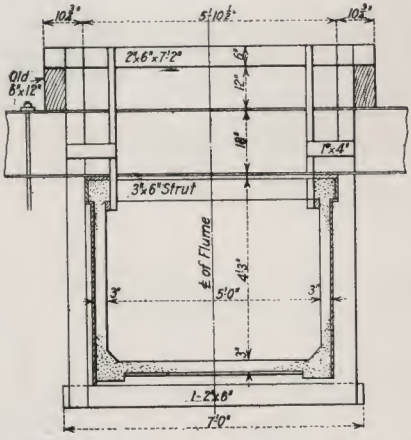
Another difficult part to shoot was the space between the forms, and the reinforcement in the side walls, which had to be watched very closely by the nozzleman so as to avoid sand pockets. In a few places such defects had to be repaired by plastering.

Considerable trouble and labor could have been avoided if local conditions would have permitted the shooting of the side walls from the outside, using inside forms. Wherever possible, wire mesh or expanded metal should be used for gunite reinforcement in preference to bars. If bar reinforcement must be used, good results can be obtained by shooting the gunite from both sides against the bars, using portable wood pannels for backing up the first coat.

In regard to carrying on guniting operations during wet and cold weather, this work has proved to the writer that it can readily be done if the work is organized for such an emergency. Wet sand with a moisture content up to 6 or 7 per cent is not objectionable, but the air used must be dried before it gets to the gun, otherwise clogging of the hose or gun will result. A simple and effective home-made air dryer that the writer has used on various gunite jobs was described by him in an article on gunite



Half Section of Flume

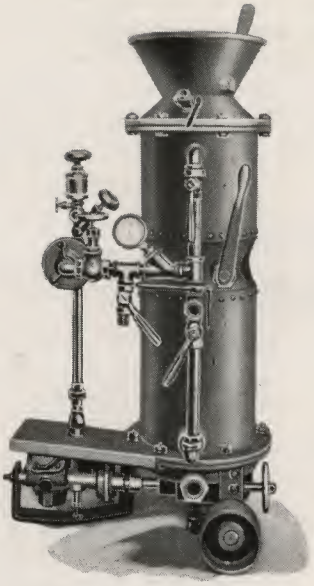


Cross Section of Forms for Flume to Bridge

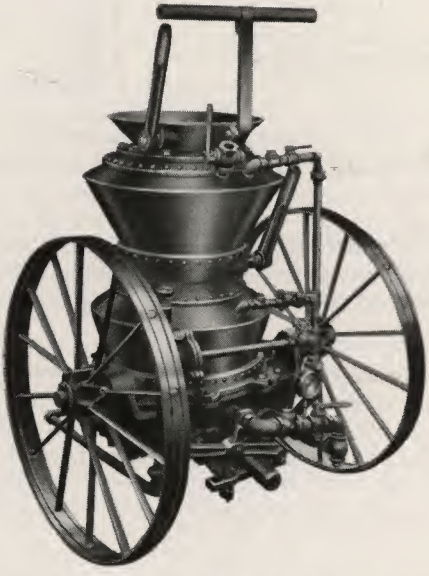
work appearing in "Engineering and Contracting," issue of April 12, 1922, and in "Engineering News-Record," issue of June 1, 1922, where also other pointers will be found in reference to designing and laying out of gunite construction work.

The gunite flume described here was completed during November, 1921, but on account of operating conditions in the Green River gravity supply system, it was not feasible to make use of it until May, 1922. The structure has passed through the temperature changes of one summer, fall and part of this winter with some very severe weather during the early part of December, without showing any sign of effects due to these weather changes.

The work was designed and constructed under the personal supervision of the writer, with O. A. Abelson as Designing and Constructing Engineer. Mr. Ira S. Davidson is the Commissioner of the Light and Water Department of the city of Tacoma.



"CEMENT GUN" TYPE N-$_{00}$



"CEMENT GUN"—TYPES No. N_1 and N_2

BULLETIN NO. 137

Searle & Bachman Co., Allentown, Pa.

Report Showing Results of Tests Made on

GUNITE SLABS

TOGETHER WITH

WORKING TABLES and SAFE LOAD TABLES

Established Through These Tests

CEMENT GUN CO., INC.

ALLENTOWN, PENNA.

FOREWORD

In 1918 the United States Shipping Board, through the Bureau of Standards, carried on a series of tests to prove the compressive strength and Modulus of Elasticity of "Gunite", the results of which tests were compiled in a paper prepared by Mr. B. C. Collier, Mem. Am. Soc. C. E., and read before the Municipal Engineers of the City of New York on December 23, 1918. As a result of this we had frequent and numerous calls for information as to the slab thicknesses and reinforcements that should be used for "Gunite" slabs under various loadings. The thicknesses and amount of reinforcement as determined by existing formulae seemed so radical that it was deemed advisable to establish by test, rather than by computation, what they should be, and toward that end a series of tests were made on 18 slabs of four foot clear span; 16 slabs of six foot clear span; and 9 slabs of eight foot clear span, all with varied percentages of reinforcement. To insure the authenticity of these tests it was arranged that they should be made under the direct supervision of Mr. M. O. Fuller, Adjunct Professor of Civil Engineering, Fritz Laboratory, Lehigh University, and Mr. George E. Strehan, Consulting Engineer, 110 West 42nd St., New York, (the engineer who developed the slab formulae now accepted as standard by the Building Department of New York City) and each series of tests was witnessed by a large number of the most prominent concrete engineers in the East.

It will be seen from the herewith published reports of both Prof. Fuller and Mr. Strehan that these tests have definitely proven that "Gunite" can be assumed to have a factor of safety of four when stressed to 1500 pounds. Also that 1 to 2½ "Gunite" slabs will have a factor of safety of four when stressed to 1800 pounds.

On these assumptions, and on the assumption of the use of a ratio of ten (10) between the modulus of elasticity of "Gunite" and that of steel (vide Report Joint Committee for values of concrete of over 4,000 pounds compressive strength), a series of tables showing the thickness of slabs and amount of reinforcement necessary for various live loads; as well as a table showing the values of different standard coefficients referred to in Hool and Johnson's Concrete Engineers Hand Book, have been prepared; and are hereby submitted to the engineering public with the assurance of perfect safety in design if these values are followed properly, as the factors of safety determined here have been based entirely on the action of the test slabs as simple beams.

A point of interest in Tables A and B of Mr. Fuller's report are the notes relative to the failure of the slabs due to the breaking of the steel. A reference to Table D will show that the computed value of *fc* from these slabs is very low in comparison to the values when the slab broke due to the failure of the "Gunite". Attention is also called to the curves showing the deflection values of "Gunite" slabs in comparison to concrete slabs tested at the same time, and also to the references regarding these deflections as contained in both reports.

In addition to the tests reported herein a great many other tests have been made throughout the country to determine the compressive value of "Gunite". Notably among these were tests made by the City of Seattle not only on slabs but also to determine the compressive values, and it is interesting to note that the report showed a compressive value of over 7000 pounds per sq. in. on 1 to 3 "Gunite". Similarly, recent tests were made at Lehigh University on "Gunite" samples from Florida and the results showed an average compressive value of over 7500 pounds per sq. in. on 1 to 3 "Gunite" made from "Lake Weir Sand", and over 7200 pounds per sq. in. on 1 to 3 "Gunite" made from fine Florida sand.

Attention is also called to the Addendum on Page 31 of this Bulletin giving information relative to tests recently made for the New York-New Jersey Tunnel Commission to determine the value of "Gunite" for building the walls of the air ducts of the Ventilation Buildings at each end of the Holland Tunnel.

Another very interesting test was made in April 1923 at Hampton (Va.) Institute under the direction of Mr. H. W. Brown, (B.S. Mass. Inst. Tech.), who is in charge of the Department of Building Construction of that institution, on a flat "Gunite" slab two inches thick reinforced equally in both directions and designed for a load of 40 pounds per sq. ft. This slab was supported on four sides by girders spaced 12 ft. apart in the clear. Precision measurements were taken to show the deflections and steel stresses. The slab was subjected to loads of different character, but finally a loading of sand was applied until a total of 150 lbs. per sq. ft. was reached when the slab was left for future determination. At 103 pounds the maximum deflection was less than one-half inch. After standing for several months the slab was tested to destruction and finally failed at the ultimate loading of over 500 pounds per sq. ft.

The photograph on the back of this Bulletin is that of Slab No. 40 referred to on Page 21. This slab was loaded to the assumed elastic limit of the steel reinforcing, and the applied load was left in place to prove the ultimate life of the slab. The photograph shows the condition of the slab at the end of two years, at which time the deflection was slightly in excess of two inches. At this date (*over six years after the load was applied*) under the same continued applied load, the slab is in the same condition as to deflection and cracking as existed at the end of the 70 days noted by Prof. Fuller.

We feel that the values of "Gunite" slabs as shown by these and other tests, as well as by the actual practice developed from the use of these tables, fully prove the great advantage and economy of the use of "Gunite" not only for roof and wall slabs, but also for floors and similar heavily loaded structures.

CEMENT GUN COMPANY, INC.,

July, 1926. Allentown, Pa.

Coefficient of Expansion Tests on "Gunite" as determined by Professor M. O. Fuller, Lehigh University in report dated January 4, 1924.

Spec. No.	Original length in inches	Room Temp. F	Highest Temp. Rec'd F	Diff. in Temp.	Mean of Two Telescope Readings Inch	Coef. Exp. per Degree F
1	6.05	57	1098	1041	.04120	.00000654
2	5.53	60	970	910	.03220	.00000644
3	5.32	60	1234	1174	.04020	.00000643
4	6.03	60	1198	1138	.04390	.00000641
5	5.83	60	1297	1237	.04637	.00000643

For full details of these tests see 1924 proceedings American Concrete Institute.

GUNITE

TABLE 1

$n = 10$

ASSUMPTIONS :- ULT. COMPRESSIVE STR 1:3 GUNITE = 4100 LBS. SQ. IN.

ULT COMPRESSIVE STR. 1:2½ GUNITE = 4800 LBS. SQ. IN

DATA FOR BALANCED PERCENTAGES OF REINFORCEMENT

$M_c = R_c b d^2$ $M_s = R_s b d^2$

TABLE	f_c	f_s	$k = \frac{1}{1+\frac{f_s}{nf_c}}$	$j = 1 - \frac{k}{3}$	$p = \frac{f_c k}{2 f_s}$	$R_c = \frac{1}{2} f_c j k$	$R_s = f_s j p$	FACTOR OF SAFTY	MIX
1	1500	20000	.429	.857	.0161	275.74	275.95	4	1:3
2	1800	20000	.474	.842	.0213	359.20	358.69	4	1:2½
3	1200	16000	.429	.857	.0161	220.59	220.76	5	1:3
4	1500	16000	.484	.839	.0227	304.56	304 72	4	1:3

p	k	j	$R_c = \frac{1}{2} f_c j k$			$R_s = f_s p j$	
			1:2½ MIX $f_c = 1800$	1:3 MIX $f_c = 1500$	1:3 MIX $f_c = 1200$	$f_s = 16000$	$f_s = 20000$
.001	.132	.956	113.5	94.6	75.6	15.3	19.1
.0015	.159	.948	130.9	113.0	87.2	22.8	28.4
.002	.181	.940	133.2	127.7	102.1	30.1	37.6
.0025	.200	.933	168.0	140.0	112.0	37.4	46.7
.003	.216	.928	180.4	150.5	120.2	44.5	55.7
.0035	.232	.923	193.0	160.7	128.8	51.7	64.7
.004	.246	.918	202.7	169.4	135.3	58.8	73.5
.0045	.259	.914	213.0	177.5	142.0	65.8	82.3
.005	.270	.910	221.5	184.3	147.4	72.8	91.0
.0055	.281	.906	229.2	190.9	153.8	79.6	99.6
.006	.292	.903	237.8	198.0	158.7	86.6	108.2
.0065	.301	.899	243.7	203.0	162.4	93.4	116.7
.007	.311	.896	250.8	209.0	167.5	100.4	125.6
.0075	.319	.894	256.8	214.0	171.2	107.2	134.0
.008	.328	.891	262.6	218.8	175.5	114.0	142.6
.0085	.336	.888	269.2	224.2	179.0	120.8	151.1
.009	.344	.885	274.2	228.5	182.8	127.6	159.5
.0095	.351	.883	279.2	232.7	186.0	134.2	167.6
.01	.358	.881	283.8	236.5	178.4	141.0	176.2
.0105	.365	.879	289.0	240.7	192.5	147.8	185.0
.011	.372	.876	293.0	244.2	195.0	154.2	193.0
.0115	.377	.874	296.8	247.5	197.6	160.8	201.2
.012	.384	.872	300.8	250.9	200.6	167.4	209.0
.0125	.390	.870	305.6	254.4	203.0	174.0	218.0
.013	.396	.868	309.7	257.8	206.0	181.5	226.0
.0135	.402	.866	313.4	260.8	208.2	187.0	234.0
.014	.407	.864	316.1	263.6	210.3	193.4	242.0
.0145	.413	.862	320.2	267.0	213.4	199.9	250.0
.015	.418	.861	324.0	270.2	216.0	206.4	258.3
.0155	.423	.859	327.7	272.9	218.0	213.0	266.5
.016	.427	.858	330.2	275.2	220.3	219.8	274.5
.0165	.433	.856	333.6	278.2	222.0	226.0	282.0
.017	.437	.854	336.0	280.2	224.0	232.0	290.0
.0175	.442	.853	339.6	282.6	226.2	239.0	298.5
.018	.447	.851	342.1	285.4	228.0	245.2	306.5
.0185	.451	.850	344.5	287.0	230.0	251.6	314.5
.019	.455	.848	348.0	289.4	232.0	257.6	322.0
.0195	.459	.847	350.0	291.6	233.6	264.6	330.0
.02	.464	.845	353.0	294.0	235.2	270.2	338.4
.0205	.467	.844	355.0	296.0	237.0	277.2	346.2
.021	.470	.843	357.0	297.5	238.0	283.5	354.0
.0215	.475	.842	360.0	300.0	2400	290.0	362.5
.022	.478	.841	362.2	302.0	241.8	296.0	370.0
.0225	.482	.839	363.9	303.0	242.2	301.8	377.0
.023	.487	.838	367.8	306.4	245.2	308.4	387.6
.024	.494	.835	371.8	309.8	247.8	320.2	401.0
.025	.500	.833	375.0	312.1	250.0	332.5	416.0
.026	.507	.831	379.0	316.0	253.0	345.0	432.0
.027	.513	.829	382.4	319.5	255.8	358.0	448.0

MAY 1, 1920 REVISED JUNE 7, 1920; AUG. 9, 1920

M. O. Fuller
LEHIGH UNIVERSITY

Geo. E. Stehan, Cons. ENGR.
112 WEST 42 ST, N.Y.C.

M.L.F.

No 1

SAFE LIVE LOADS FOR GUNITE SLABS

NON-CONTINUOUS MESH REINFORCEMENT

GUNITE AT 1500 LBS. SQ. IN. 1:3 MIX FACTOR OF SAFTY = 4
STEEL AT 20000 LBS. SQ. IN.

TOTAL THICKNESS OF SLAB IS GIVEN IN LARGE BLOCK NUMERALS. UNDER GIVEN SPAN AND OPPOSITE DESIRED LIVE LOAD, FIND THE AREA OF REINFORCEMENT REQUIRED PER FOOT OF WIDTH OF SLAB.

FOR SLABS 2½ INCHES OR LESS IN THICKNESS, ONE HALF (½) INCH IS ALLOWED FROM BOTTOM OF SLAB TO CENTER OF STEEL FOR PROTECTION, AND THREE-QUARTER (¾) INCHES FOR SLABS GREATER THAN 2½ INCHES IN THICKNESS.

IT IS RECOMMENDED THAT A TOTAL THICKNESS OF TWO (2) INCHES BE EMPLOYED AS A MINIMUM FOR FLOOR SLABS AND ONE AND ONE HALF (1½) INCHES FOR ROOF SLABS

SPAN LBS. PER SQ. FT.	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"
30	.035	.050	.065	.080	.100	.125	.145	.145	.17	.200	.200
40	.040	.060	.080	.100	.120	.150	.150	.185	.205	.205	.225
50	.055	.075	.090	.120	.145	.180	.18	.215	.205	.240	.275
60	.060	.080	.110	.135	.170	.170	.225	.225	.240	.275	.275
70	.065	.090	.120	.155	.155	.190	.190	.225	.270	.270	.310
80	.075	.100	.135	.195	.170	.210	.215	.255	.260	.300	.300
90	.080	.115	.150	.155	.190	.185	.235	.240	.285	.295	.333
100	.095	.120	.165	.170	.210	.215	.260	.260	.310	.330	.360
110	.095	.130	.180	.185	.190	.235	.240	.285	.295	.340	.360
120	.105	.135	.155	.200	.205	.250	.260	.310	.320	.370	.385
130	.115	.155	.165	.210	.220	.235	.280	.290	.340	.355	.405
140	.120	.170	.175	.225	.235	250	.260	.310	.360	.370	.440
150	.130	.180	.190	.200	.250	.260	.275	.330	.350	.405	.420
160	.140	.190	.200	.220	.265	.280	.295	.350	.370	.430	.445
170	.145	.160	.215	.225	.240	.295	.310	.365	.390	.405	.465
180	.155	.170	.185	.240	.255	.275	.325	.350	.415	.430	.445
190	.125	.185	.195	.210	.270	.290	.345	.365	.385	.450	.470
200	.135	.190	.205	.220	.245	.300	.360	.385	.405	.430	.490

1 1/2 2 2 1/4 1 3/4 2 1/2 3 3 1/4 3 1/2

NOTE:- FOR TOTAL LOAD ON STRUCTURAL FRAMEWORK ADD WEIGHT OF SLAB TO LIVE LOAD AT 12 LBS. FOR EACH INCH THICKNESS. TO OBTAIN TOTAL SAFE LOAD FOR CONTINUOUS MESH REINFORCEMENT, ADD 50 PER. CENT.

M. J. Fuller ENGINEER-IN-CHARGE

Geo. E. Stecher. CONS. ENGR. 112 West 42 St. N.Y.C.

Aug. 7, 1920.

No 2

SAFE LIVE LOADS FOR GUNITE SLABS

NON-CONTINUOUS MESH REINFORCEMENT

GUNITE AT 1800 LBS. SQ IN. STEEL AT 20000 LBS. SQ. IN 1:2½ MIX FACTOR OF SAFTY = 4

TOTAL THICKNESS OF SLAB IS GIVEN IN LARGE BLOCK NUMERALS. UNDER GIVEN SPAN AND OPPOSITE DESIRED LIVE LOAD, FIND THE AREA OF REINFORCEMENT REQUIRED PER FOOT OF WIDTH OF SLAB.

FOR SLABS 2½ INCHES OR LESS IN THICKNESS, ONE HALF (½) INCH IS ALLOWED FROM BOTTOM OF SLAB TO CENTER OF STEEL FOR PROTECTION, AND THREE-QUARTER (¾) INCHES FOR SLABS GREATER THAN 2½ INCHES IN THICKNESS.

IT IS RECOMMENDED THAT A TOTAL THICKNESS OF TWO(2) INCHES BE EMPLOYED AS A MINIMUM FOR FLOOR SLABS AND ONE AND ONE-HALF (1½) INCHES FOR ROOF SLABS.

LIVE LOAD PER Sq. Ft. \ SPAN	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"
30	.035	.050	.065	.080	.100	.125	.150	.175	.170	.200	.200
40	.045	.060	.075	.100	.125	.150	.185	.175	.205	.240	.240
50	.050	.070	.090	.115	.145	.180	.180	.210	.245	.285	.275
60	.060	.080	.105	.135	.170	.210	.200	.240	280	.275	.315
70	.065	.090	.120	.155	.190	.190	.230	.270	.270	.310	.356
80	.075	.100	.135	.175	.215	.210	.255	.255	.300	.345	.345
90	.080	1½ .115	.150	.190	.190	.235	.285	.280	2 .330	.330	.380
100	.090	.125	.165	.210	.210	.255	.260	.305	.360	.360	.412
110	.095	.135	.180	.230	.230	.280	.280	.335	.335	.390	.447
120	.105	.145	.195	.200	.250	.300	.305	.360	.365	.370	.420
130	.115	.155	210	.210	.265	.300	.325	.330	.390	.395	.455
140	.120	.165	.175	1¾ .225	.285	.290	.350	.355	.415	.420	.480
150	.130	.180	.190	.240	.300	.310	370	.385	2½ .385	.450	.511
160	.135	.190	.200	.260	.265	.325	.340	.400	.410	.475	.490
170	.145	.205	.215	.275	.285	.345	.355	.370	.430	.505	.520
180	.150	.215	.225	.240	.300	.310	.325	.390	.435	.475	.545
190	160	.180	.235	.250	.265	2¼ .330	.395	.405	.430	3 .495	.515
200	.170	.185	.250	.260	.280	.345	.415	.425	.450	.525	3¼ .540

NOTE :- FOR TOTAL LOAD ON STRUCTURAL FRAMEWORK ADD WEIGHT OF SLAB TO LIVE LOAD AT 12 LBS. FOR EACH INCH THICKNESS.
TO OBTAIN TOTAL SAFE LOAD FOR CONTINUOUS MESH REINFORCEMENT ADD 50 PER CENT.

AUG. 7, 1920

M. O. Fuller
LEHIGH UNIVERSITY

Geo. E. Strehan. CONS. ENGR.
112 WEST 42 ST. N.Y.C.

A.L.T.

No 3

SAFE LIVE LOADS FOR GUNITE SLABS

NON-CONTINUOUS MESH REINFORCEMENT

GUNITE AT 1200 LBS. SQ. IN.
STEEL AT 16000 LBS. SQ. IN.

1:3 MIX

FACTOR OF SAFTY = 5

TOTAL THICKNESS OF SLAB IS GIVEN IN LARGE BLOCK NUMERALS. UNDER GIVEN SPAN AND OPPOSITE DESIRED LIVE LOAD, FIND THE AREA OF REINFORCEMENT REQUIRED PER FOOT OF WIDTH OF SLAB.

FOR SLABS 2½ INCHES OR LESS IN THICKNESS, ONE HALF (½) INCH IS ALLOWED FROM BOTTOM OF SLAB TO CENTER OF STEEL FOR PROTECTION, AND THREE-QUARTER (¾) INCHES FOR SLABS GREATER THAN 2½ INCHES IN THICKNESS.

IT IS RECOMMENDED THAT A TOTAL THICKNESS OF TWO (2) INCHES BE EMPLOYED AS A MINIMUM FOR FLOOR SLABS AND ONE AND ONE-HALF (1½) INCHES FOR ROOF SLABS

SPAN & LBS. PER SQ. FT.	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0	6'-6"	7'-0"	7'-6"	8'-0"
30	.050	.060	.080	.100	.130	.130	.135	.160	.190	.220	.241
40	.055	.075	.100	.125	.130	.160	.160	.195	.225	.260	.265
50	.065	.090	.115	.150	.150	.185	.190	.225	.260	.265	.305
60	.075	.100	.135	.170	.175	.215	.215	.260	.260	.305	.310
70	.085	1 .115 1½	.150	.160	.195	.205	.245	.290	.295	.305	.350
80	.090	.130	.170	.175	.220	.225	.280	.280	.330	.335	.355
90	.105	.140	.150	.195	.220	.250	.260	.310	.315	.350	.390
100	.115	.155	.165	.215	.230	.270	.285	.295	.345	.370	.425
110	.120	.170	.180	.195	.245	.250	.305	.320	.345	3 .395	.415
120	.135	.185	.195	.210	2 .260	.275	.330	.345	.370	.418	.445
130	.140	.160	.210	.225	.280	.295	.310	2½ .370	.395	.410	.470
140	.155	1 .170 ¾	.225	.240	.260	.315	.335	.355	.420	.440	.460
150	.165	.180	.200	.255	2¼ .275	.335	.350	.380	.400	.465	.485
160	.175	.185	.210	.230	.290	.310	.370	.395	3¼ .425	.445	.510
170	.185	.200	.220	.245	.305	.330	.355	.425	.445	3½ .470	.495
180	.155	.215	.235	.260	.280	.345	.375	.400	.470	.495	.520
190	.160	.225	.250	.270	.295	.325	.395	.420	.415 3¾	.475	.545
200	.175	.195	.260	.285	.305	.340	.415	.440	.430	.500	.570

NOTE:- FOR TOTAL LOAD ON STRUCTURAL FRAME WORK ADD WEIGHT OF SLAB TO LIVE LOAD AT 12 LBS. FOR EACH INCH THICKNESS. TO OBTAIN TOTAL SAFE LOAD FOR CONTINUOUS MESH REINFORCEMENT ADD 50 PER CENT.

AUG. 7, 1920.

M. O. Fuller
LEHIGH UNIVERSITY

Geo. E. Thelan, CONS. ENGR.
112 WEST 42 ST. N.Y.C.

A.A.E.

No 4

SAFE LIVE LOADS FOR GUNITE SLABS

NON-CONTINUOUS MESH REINFORCEMENT

GUNITE AT 1500 LBS. SQ. IN
STEEL AT 16000 LBS. SQ. IN

1:3 MIX FACTOR OF SAFTY = 4

TOTAL THICKNESS OF SLAB IS GIVEN IN LARGE BLOCK NUMERALS UNDER GIVEN SPAN AND OPPOSITE DESIRED LIVE LOAD, FIND THE AREA OF REINFORCEMENT REQUIRED PER FOOT OF WIDTH OF SLAB.

FOR SLABS 2½ INCHES OR LESS IN THICKNESS, ONE HALF (½) INCH IS ALLOWED FROM BOTTOM OF SLAB TO CENTER OF STEEL FOR PROTECTION, AND THREE-QUARTER (¾) INCHES FOR SLABS GREATER THAN 2½ INCHES IN THICKNESS.

IT IS RECOMMENDED THAT A TOTAL THICKNESS OF TWO (2) INCHES BE EMPLOYED AS A MINIMUM FOR FLOOR SLABS AND ONE AND ONE-HALF (1½) INCHES FOR ROOF SLABS

SPAN / Lbs PER Sq. Ft.	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"
30	.045	060	.080	.100	.124	.155	.185	.220	.215	.250	.290
40	.055	.075	.095	.125	.155	192	220	.225	.260	.305	.240
50	.060	085	.115	.150	.185	.230	.225	.260	305	.300	.330
60	.075	.100	.135	.170	.215	.265	.255	.300	.300	.350	.400
70	.085	.115	.150	.195	.245	.240	.290	290	.340	.325	.390
80	.090	.130	.170	.220	.220	270	.330	.320	.375	.380	.435
90	.100	.140	1½ .190	.240	.245	.300	.300	.355	.360	.415	.420
100	.110	.155	.210	.265	.280	.325	.340	.390	.390	.465	.460
110	.120	.165	225	.230	.290	.295	355	.365	.425	.435	.500
120	.135	.185	.245	.250	.315	.320	2 .385	.390	.405	.465	.535
130	.145	.200	.265	.270	.335	.345	.350	.420	.430	.500	.520
140	.155	.215	.225	.290	.300	.370	.380	.445	2½ .460	.535	.555
150	.165	.230	1¾ .240	.305	.320	.390	2¼ .405	.480	.485	.510	.590
160	.175	.240	.255	.325	.340	.350	.425	.445	.520	.545	3 .645
170	.185	.255	.270	.285	.360	.372	.450	.465	.495	.520	.595
180	.194	.270	.285	.300	.380	.400	.480	.495	.520	.605	.620
190	.205	.235	.300	315	.400	.415	.435	.520	.545	.570	.655
200	.215	.235	.315	.335	.355	.435	460	.545	.570	3¼ .600	.690

NOTE:- FOR TOTAL LOAD ON STRUCTURAL FRAME WORK ADD WEIGHT OF SLAB TO LIVE LOAD, AT 12 LBS. FOR EACH INCH THICKNESS.
TO OBTAIN TOTAL SAFE LOAD FOR CONTINUOUS MESH REINFORCEMENT ADD 50 PER. CENT.

Aug. 7, 1920

M. O. Fuller
LEHIGH UNIVERSITY

Geo. E. Stecham, Cons. Engr.
112 WEST 42 ST NYC

GEO. E. STREHAN
Asso. Mem. A. S. C. E.

CONSULTING ENGINEERS

112 WEST 42nd STREET
New York City

Telephone
BRYANT 1208

July 10, 1920

SUBJECT: GUNITE SLABS.

Mr. B. C. Collier,
Cement-Gun Company.
Allentown, Pa.

Dear Sir:-

I have made an analysis of the data obtained in the load tests of Gunite Slabs conducted at Allentown, Pa., on January 20-21, March 12-13 and May 7-8, 1920. This data indicates some inconsistencies with the generally accepted theories, particularly in the case of short spans and thin slabs reinforced with a light percentage of steel. Similar discrepancies have, however, been observed in other tests of reinforced concrete slabs on short spans. The strength of such slabs apparently depends upon the compressive strength of the concrete to a greater degree than would be indicated by the usually accepted composite theory of flexure. Had these tests of Gunite Slabs been made on specimens constructed as they are actually to be used in practice, the difficulty of reconciling theory and practice would have been still greater. In short span work in New York City for fireproof construction between steel beams, the common theory of flexure is entirely disregarded.

The permissible values to be used for the extreme fibre stress of Gunite in flexure are based on the tests of the slabs, using a factor of safety of 4 for the ultimate load carrying capacity. It will be noted that the fibre stress recommended for design purposes, which gives a working load of approximately the ¼ ultimate test load, is about 37 per cent. of the assumed compressive strength of Gunite. This is very closely in accord with the recommendations of the American Concrete Institute, which specify a working fibre stress of 37½ per cent, of the ultimate compressive strength of concrete.

Mr. B. C. Collier, No. 2.

The value assumed for the ratio of the moduli, is based on general knowledge of the action of reinforced concrete in tests and the results obtained in your series of Gunite slab tests, as well as the recommendation of the Joint Committee. It is, to some extent, predicated on the assumed value for permissible fibre stress in Gunite. With an extreme fibre stress of 1500 lbs. per square inch in compression and a value of 20,000 lbs. per square inch for the tensile working stress in the steel, values of n have been computed which give the deflections that obtained in the tests at working load stages. Such computations gave values varying from 10 to 12 for the different slabs. Those values of n are computed on the basis of an accurate measurement of the deflection during the first stage of the load deformation curve, along that region of the curve in which working loads occur.

It has always been the practice to assume a smaller value for the coefficient of elasticity than that obtained either from cylinders or prisms in compression tests or tests on unreinforced slabs. Tests of ordinary 1-2-4 stone concrete with a compressive strength of 2000 lbs. per square inch at twenty-eight days show a modulus of approximately 3,000,000 lbs. per square inch and sometimes higher. Similarly, for 1:2:5 cinder concrete, moduli have been obtained as high as 2,000,000 lbs. and 3,000,000 lbs. per square inch. This would indicate a ratio n—10 for stone and cinder concrete. Yet in reinforced concrete design, ratios of 15 and 30, respectively, are usually assumed for stone and cinder concrete. Your paper presented before the Municipal Engineers of the City of New York quotes a value of 4,705,000 lbs. per square inch for 1-:3 Gunite obtained from eight tests of prisms. Inasmuch as the tensile value of concrete is ordinarily neglected in the design of reinforced concrete beams and slabs in flexure, it is customary to assume a smaller value of the coefficient of elasticity than shown by prism tests, to compensate for this neglect. This is equivalent to assuming a larger ratio of Es to Eg, thus lowering the apparent location of the neutral axis.

Based on the first and second series of tests, of January 20 and March 12, 1920, a set of design tables was prepared on the following assumptions:

n—10—Ratio of Moduli of elasticity
fc—1330 lbs. per sq. in. for 1:3 Gunite—Extreme fibre stress
fc—1560 lbs. per sq. in. for 1:2½ Gunite—Extreme fibre stress
fs—16,000 lbs. per sq. in. for mild steel—Working stress
fs—20,000 lbs. per sq. in. for cold drawn mesh—Working stress.

On these assumptions, the computed working loads gave an average factor of safety for all tests as follows:-

4.16 for 1-3 Gunite
4.85 for 1-2½ Gunite

The corresponding critical or balanced steel percentage was approximately 1¼ per cent.

From the data obtained in the May 7, 1920, series of tests, which developed some excellent results, it appeared that the permissible fibre stress in compression could be considerably increased. It is therefore now recommended that the following working stresses and constants be used:—

n—10
fc—1500 lbs. per sq. in. for 1:3 Gunite
fc—1800 lbs. per sq. in. for 1:2½ Gunite
fs—16,000 lbs. per sq. in. for mild steel
fs—20,000 lbs. per sq. in. for cold drawn mesh

The computed live loads under these assumptions show an average factor of safety for all test loads of approximately 4 for the 1:3 Gunite and 4.85 for the 1:2½ Gunite.

Mr. B. C. Collier, No. 4

The data submitted by you on Slab No. 27 did not state the nature of the failure. It has been assumed, however, that the failure was entirely in the steel. In the interval of seven days during which this slab was permitted to rest with a load of 7756 lbs. superimposed, the deflection increased from approximately 7/16" to 5/8". The higher ultimate carrying capacity of this slab as compared with Slab No. 35 might be accounted for by the increase in effective depth of the steel, due to this deflection. It should be noted, however, that the load during this period of rest was more than twice the computed working load, making the above result rather unusual and unexpected.

Under the assumptions recommended for analysis and design of the Gunite Slabs, it will be found that the critical or balanced percentage of steel is approximately 1 5/8 per cent. This bears out very well the observed failure in Slabs Nos. 31, 37, 44, 45, 46, 47 and 48. Tensional steel failures occured in slabs reinforced with from ½% to 1 2-3% of steel. Above this percentage the failures were either composite or compression failures. In some cases, due to a slight unbalancing of the load over the two bearing points, excessive shears were produced under one of the roller bearings, which had an effect on the character of the ultimate fracture. In Slab No. 41, reinforced with 2.08% of steel, failure apparently occured solely in the reinforcement, but this result is probably abnormal or else an error was made in observation. It has since been discovered that the size and weight of the steel reinforcement used in this slab was incorrectly specified by the manufacturer.

The reinforcement used was expanded metal mesh and all percentages of reinforcement were computed on the basis of area of equivalent longitudinal steel. The effective area of reinforcement is, therefore, the area of the diagonal strands multiplied by the cosine of the angle of inclination of such strands to the longitudinal axis or span. In the computations for permissible live loads, the working stress applied to this reinforcement was 20,000 lbs. per square inch, and the areas of reinforcement used were those given by the manufacturer, which were found to practically check up the measured weight of steel.

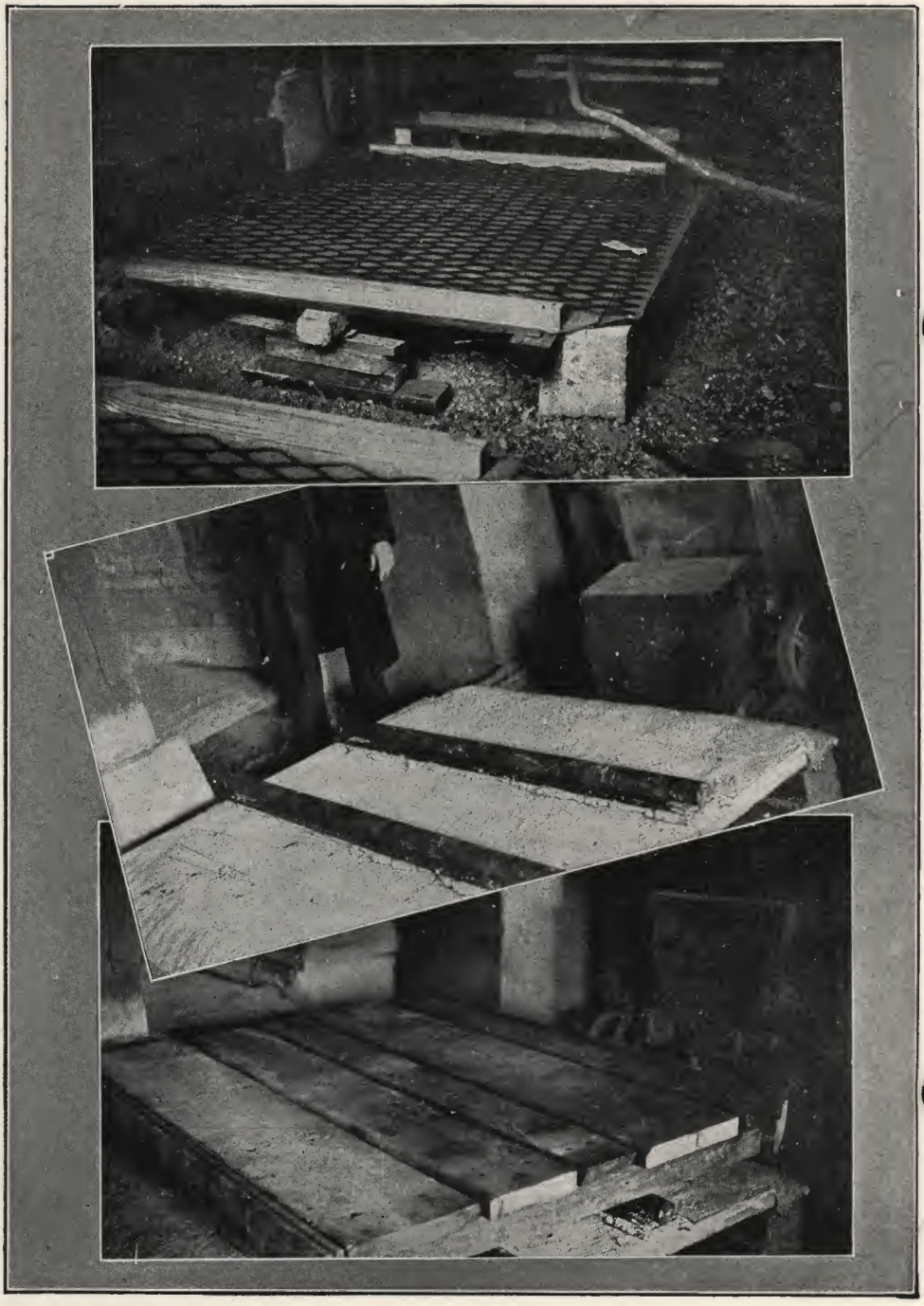
On the 4′–0″ spans, the last measured deflections varied from ½ to ⅝″; on the 6′–0″ spans, from 1 to 1½ inches, and on the 8′—0″ spans, from 2½ to 3 inches, or approximately 1—80, 1–60 and 1–40 of the spans, respectively. It varied inversely with percentage of reinforcement and thickness of slab. Permissible deflections of these slabs built between rigid beams or supports should be limited to a maximum of 1–600 to 1–800 of the span for working loads. In the tests of Gunite slabs, deflections at working loads were frequently inappreciable.

Submitted herewith is a table showing, the proposed resisting moments based on Gunite and Steel for different percentages of reinforcement, with which table the working load of any combination of Gunite and Steel up to 2% of reinforcement can be computed. In addition to this, I would recommend either a graph showing area of steel required for different thicknesses of slabs for specified working loads, spans, thickness of slab and reinforcement. The table herewith offered is based on the assumptions above recommended, which bear out the test data as well as could be expected. I have had prepared Table No. 2 to show the required values for extreme fibre stress in Gunite to balance the steel reinforcement at percentages of 1¼, 1½, 1⅝ and 1¾ per cent., respectively, on the assumption of the lower value for n obtained from the prism tests, that is, a value of n—6½. It will be observed that this assumption does not check the results obtained in the test. The assumptions recommended for design may not be absolutely correct, yet many other acceptable methods of design which are theoretically unsubstantiated are being used to-day and are giving safe results. Such methods of design are based on assumptions obtained from a study of the built-up member under test, to determine values to be used for the various constants entering into the application of the common theory of flexure. I believe that you have succeeded in establishing satisfactory values to be recommended for use in the design of reinforced Gunite on short span work.

Yours very truly,

Geo. E. Strehan

GEO. E. STREHAN,
Consulting Engineer.



UPPER—Reinforcement and supporting panel in place between concrete supports
MIDDLE—Method of placing bars and rollers for applying loads
LOWER—Platform on top of rollers before load was applied

LEHIGH UNIVERSITY
DEPARTMENT OF CIVIL ENGINEERING
FRITZ ENGINEERING LABORATORY
MERTON O. FULLER
ASSISTANT PROFESSOR OF CIVIL ENGINEERING

July 14, 1920.

Cement Gun Co.,
Allentown, Pa.

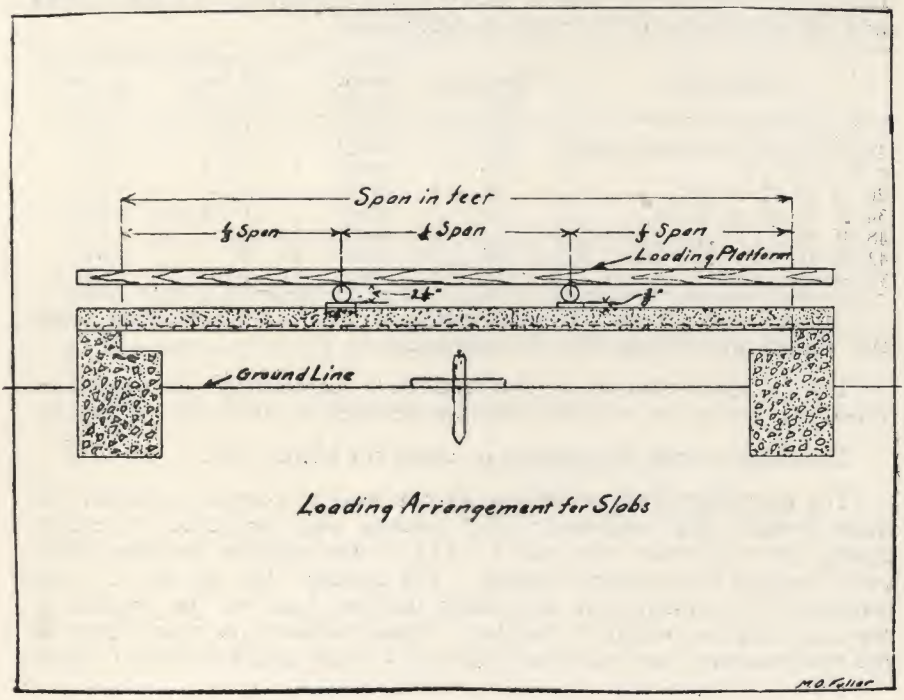
Attention Mr. B. C. Collier

Gentlemen:—

This report covers the making and testing of 43 Gunite slabs and 2 concrete slabs for the Cement Gun Co., of Allentown, Pa., Mr. B. C. Collier, General Manager.

Materials.

The cement used in shooting the slabs consisted of equal parts of four brands, viz: Alpha, Atlas, Lehigh and Pen Allen. The sand was described by the shipper at Succasunna, N. J., as "Bank Sand," and was "pumped into cars from under water." The reinforcing steel was expanded metal, furnished by the Consolidated Expanded Metal Companies of Braddock, Pa., Mr. A. V. Spinosa, V. P., and Sec., and Chief Engineer. Crushed limestone was used in the concrete slabs. Test of the materials used in both gunite and concrete slabs are given in Appendix A.



Loading Arrangement for Slabs

Forms.

The forms consisted of two concrete blocks with a cribbing blocked up on a shelf in the blocks, a steel plate on top of the cribbing and building paper over the steel plate. Strips were laid along the steel plates at the ends to give the desired thickness.

Method of Shooting.

The composite cement and sand were mixed dry, screened thru a ⅜" square mesh and supplied to the gun hopper. The slabs were shot into the forms in one operation, the air pressure 20-22 lbs. per sq. in., and the water pressure 50-60 lbs. per sq. in.

Method of Testing.

Two 3" x 7-16" x 5' steel plates were laid in gypsum at the third points of the span, 2¼" diameter rollers placed thereon, and then a wooden platform rested on the rollers. Pig iron was weighed and placed on the platform, the successive layers being at right angles to each other. A drawing attached to this report shows the arrangements.

Results.

The following tables of Series A, B, and C give the results of the tests. The area of the steel reinforcing mesh was determined by recording the length and weight of several sample strands from each size and then reducing to the area per foot of width. The following table gives the nominal area as shown in the manufacturer's hand books and the actual area of the mesh as determined.

Slabs Nos.	Nominal Area	Area Single Strand	No. strands per foot of width	Actual area per foot of width
7, 11, 18, 4, 5, 6	.10	.01325	10 2-3	.129
15, 19, 20, 12, 13, 14, 30, 29, 36,	.15	.01425	10 2-3	.139
8, 9, 10, 1, 2, 3	.20	.01805	10 2-3	.176
26, 24, 25, 22, 21, 23	.25	.0258	10 2-3	.251
34, 27, 35, 43, 44, 37, 31	.30	.02875	10 2-3	.280
48, 45, 46	.40	.0509	8	.382
42, 47, 41	.45	.0593	8	.445
39, 38, 40	.50	.0676	8	.506

.10, .15, .20, .25 and .30 (nominal) had 2¼" x 5" diamonds, while the .40, .45 and .50 had 3" x 8" diamonds.

Test of single strands of the steel show an average yield point of 57600 lbs. per sq. in., and an ultimate strength of 70700 lbs. per sq. in.

The percent steel was computed using the actual area.

The maximum load column gives the load in pounds at which the slabs broke. The equivalent load column was computed by multiplying the maximum test load by 133.33 the relation between third point loading and uniform loading. The column "lbs. per sq. ft." was computed by dividing the equivalent uniform load by the product of the span and the width of the slab. These tables show that failure of the reinforcement occured in all slabs of 4' span and all of the 6' span

slabs except two, while a composite failure of reinforcement and gunite occured in the 8′ span slabs. The latter would indicate that the critical point in both steel and gunite had been reached with a reinforcement of .40 sq. in. per foot of width for a 2½″ slab on 8′ span and .45 and .50 sq. in. per foot of width for a 3″ slab on 8′ span.

The accompanying Fig. 1, 2, (Pages 29 and 30) and 3, show the load deflection curves for the various slabs. The uniform load does not include the weight of the slab. Each curve is marked and where more than one slab number is given, the curve is the composite curve for the slabs marked on the curve.

Table D. (See pages 22 and 23).

The accompanying table D gives the values of *k*, *j*, *fs* and *fc*., computed by the formulas given on page 277 of Concrete Engineers' Handbook by Hool and Johnson, 1st edition, 1918. In accordance with a recent decision of the Joint Committee, the value of 10 for *n* was used.

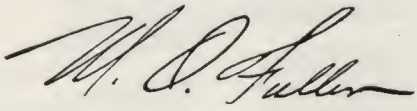
The maximum applied breaking load having been reduced to equivalent uniform load, it was then divided by a factor of safety of 4, to which was added the weight of the slab based upon 160 lbs. per cu. ft. as the weight of gunite. The bending moment (B. M.) was then computed by the formula $\frac{1}{8}WL$.

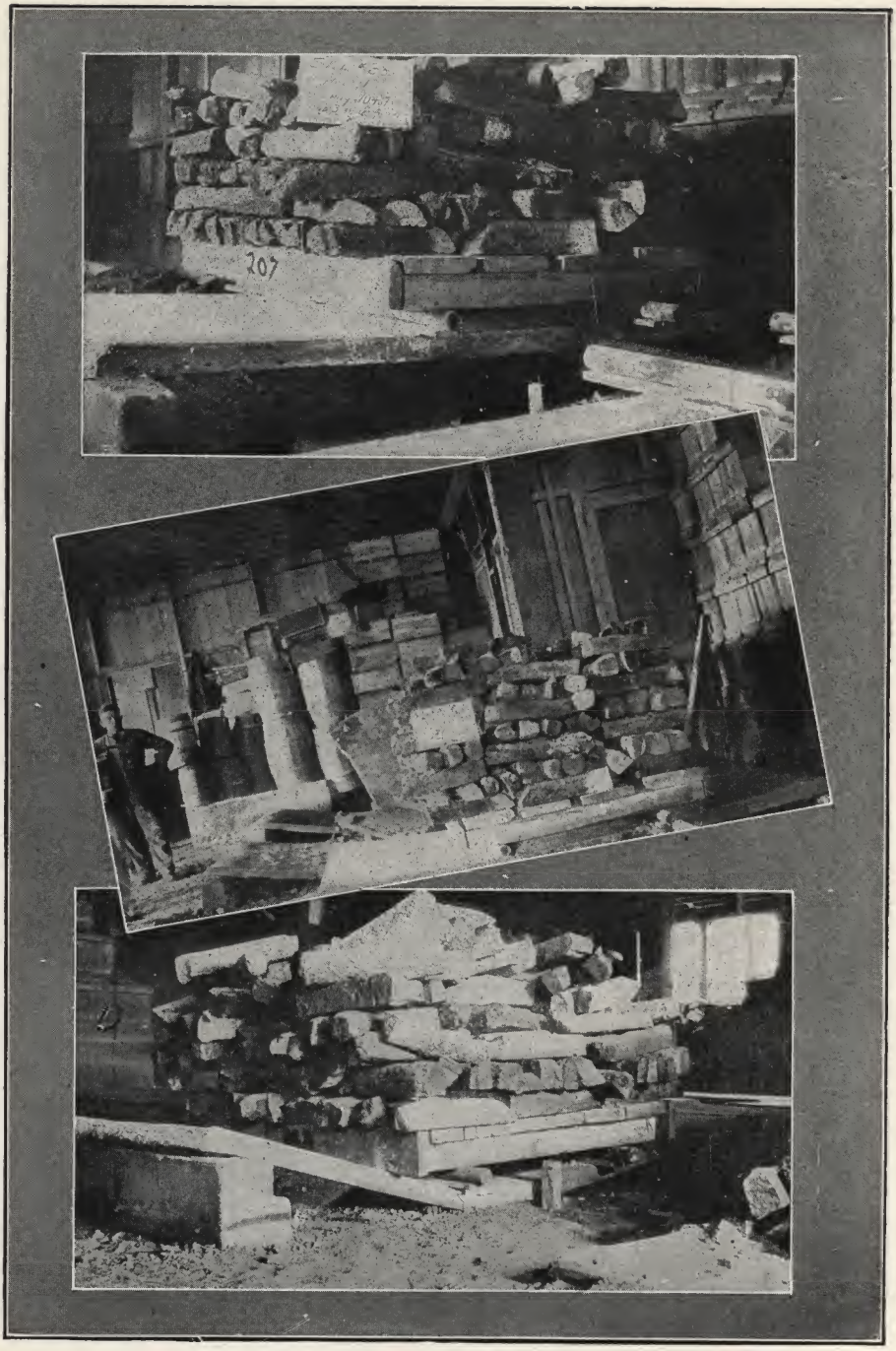
In working with the above referred-to load of one-fourth the total breaking load it will be seen that in the very much under reinforced slabs the developed values of *fc* and *fs* are very much below the definitely established ratings of either Gunite or steel, and in those slabs where there was a high percentage of steel, the actual developed values of both the Gunite and the steel were in accord with a rating of about 1500 for a working value of Gunite and about 20,000 for a working value of the steel.

Concrete Slabs.

At the same time that the 6′ span gunite slabs were shot, two (Nos. 32 and 33) concrete slabs were made. A 1-2-4 mixture, using crushed limestone, was used with the same kind of sand and cement as in the gunite slabs. Slab No. 32 was reinforced with 0.25 sq. in. per foot of width mesh, and No. 33 with 0.15 sq. in. per foot of width mesh.

Respectfully submitted,





Method of Loading. Deflections Read at Increments of about 500 lbs.

GUNITE SLABS

Series A **Span 4′ Width 5′.**

Mix 1-2½

Slab No.	Thickness ins.	Eff. Depth ins.	Steel Reinforcement	Per cent Steel	Max. Load lbs.	Equiv-unif. load	lbs. sq. ft.	Age Days	Remarks
7	2	1.625	.129	.66	9500	12650	632	29	Steel failure
11	2	1.625	.129	.66	8847	11820	591	29	" "
18	2	1.625	.129	.66	10705	14300	715	29	" "
15	2	1.625	.139	.714	10453	13900	695	39	" "
19	2	1.625	.139	.714	11184	14900	745	28	" "
20	2	1.625	.139	.714	11915	15900	795	39	" "
8	2	1.625	.176	.904	13130	17500	875	30	" "
9	2	1.625	.176	.904	12493	16700	835	29	" "
10	2	1.625	.176	.904	10394	13850	693	29	" "

Mix 1-3

Slab No.	Thickness ins.	Eff' Depth ins.	Steel Reinforcement	Per cent Steel	Max. Load lbs.	Equiv-unif. load	lbs. sq. ft.	Age Days	Remarks
4	2	1.625	.129	.66	7373	9850	493	30	Steel failure
5	2	1.625	.129	.66	9040	12000	600	29	" "
6	2	1.625	.129	.66	9131	12180	609	30	" "
12	2	1.625	.139	.714	10465	13950	697	29	" "
13	2	1.625	.139	.714	8722	11600	580	29	" "
14	2	1.625	.139	.714	8811	11750	583	40	" "
1	2	1.625	.176	.904	12352	16500	825	30	" "
2	2	1.625	.176	.904	10301	13720	686	29	" "
3	2	1.625	.176	.904	11832	15800	790	29	" "

GUNITE SLABS

Series B Span 6′ Width 3′9″

Mix 1-3

Slab Nos.	Thickness ins.	Eff. Depth ins.	Steel reinforcement	Per cent Steel	Max. Load lbs.	Equiv-unif. load	lbs. sq. ft.	Age Days	Remarks
30	2.25	1.875	.139	.618	5839	7785	346	28	Steel failure
29	2.25	1.625	.130	.714	4810	6420	286	28	" "
36	2.00	1.4375	.139	.805	4340	5780	256	28	
26	2.50	1.875	.251	1.11	8415	11220	499	28	" "
24	2.50	1.8375	.251	1.14	7903	10537	468	28	" "
25	2.50	1.6875	.251	1.24	7821	10428	463	28	" "
34	2.50	1.8125	.280	1.28	8632	11509	511	28	" "
27	2.50	1.75	.280	1.33	14770	19600	870	36	" "
35	2.50	1.75	.280	1.33	9702	12956	575	28	" "
43	2.125	1.6875	.280	1.38	6658	8900	395	28	Steel & Gunite Failure
44	2.00	1.5625	.280	1.49	6530	8700	386	28	" "
22	2.00	1.375	.251	1.52	5115	6820	303	28	Steel failure
37	2.00	1.50	.280	1.55	6716	8950	398	28	" "
21	2.00	1.25	.251	1.67	5750	7667	341	28	" "
23	2.00	1.25	.251	1.67	5051	6735	300	28	" "
31	2.00	1.3125	.280	1.78	5555	7407	330	27	" "

Notes on Series B—

Slab No. 27 was loaded to 6211 lbs. (368 lbs. per sq. ft.) when 29 days old, the deflection at this time being 7-16″. This load was then left on the slab for seven days at which time the deflection had increased to nearly $\frac{5}{8}$″. The loading of the slab was then resumed, it breaking under a load of 14770 lbs. (870 lbs. per sq. ft.)

GUNITE SLABS

Series C Span 8′ Width 4′

Mix 1-3

Slab No.	Thickness in.	Eff. Depth in.	Steel reinforcement	Per cent Steel	Max. Load Lbs.	Equiv. unif. Lbs.	Lbs. sq. ft.	Age Days	Remarks
48	2.625	2.125	.382	1.50	10062	13450	420	28	Gunite failure
45	2.50	2.00	.382	1.59	9342	12450	390	28	" "
39	3.125	2.625	.506	1.60	14570	19400	605	28	" "
46	2.625	1.9375	.382	1.64	8350	11150	348	28	" "
42	3.00	2.25	.445	1.65	12816	17100	535	28	St. & Gun. fail.
47	2.875	2.25	.445	1.65	10732	14300	447	28	Gunite failure
38	3.125	2.50	.506	1.69	14737	19700	615	28	St.& Gun. fail.
40	3.250	2.50	.506	1.69					See note
41	3.00	2.00	.445	1.85	11808	15750	490	29	Steel failure

Notes on Series C—

Slab No. 40 was loaded to 10686 lbs. (440 lbs. per sq. ft.) when 29 days old, the deflection at this time being 29-32″. The above load was then left on the slab for future examination.

Under this load of 10686 lbs. the equivalent uniform load is 14200 lbs. Cracks had appeared at the center and under both rollers.

July 17, 1920—Examined slab today, after it had been loaded 70 days, found no increase in cracks, and deflection to be 1¾″. This evidently indicated a gradual stretching of the steel as it was loaded to practically the yield point of the steel.

Table D

See Note Page 17

4′ span—6′ width n—10

1-2½ mix

Slab No.	Wt. per ft. of Width	Applied Breaking Load per ft. of Width	Total Load per ft. of Width	B. M.	Eff. Depth	% Steel	k	j	fs	fc
7	109	632	741	4446	1.625	.66	.303	.899	23600	1030
11	109	596	705	4230	1.625	.66	.303	.899	22500	985
18	109	715	824	4944	1.625	.66	.303	.899	26200	1150
15	110	695	805	4830	1.625	.714	.313	.896	21900	1080
19	110	745	855	5130	1.625	.714	.313	.896	23300	1150
20	110	795	905	5430	1.625	.714	.313	.896	24700	1220
8	111	875	986	5916	1.625	.904	.344	.886	23300	1220
9	111	835	946	5676	1.625	.904	.344	.886	22400	1170
10	111	692	803	4818	1.625	.904	.344	.886	19000	998

1-3 mix

4	109	492	601	3606	1.625	.66	.303	.899	19100	837
5	109	600	709	4254	1.625	.66	.303	.899	22600	990
6	109	609	718	4308	1.625	.66	.303	.899	22800	1000
12	110	697	807	4842	1.625	.714	.313	.896	22000	1090
13	110	580	690	4140	1.625	.714	.313	.896	18800	933
14	110	587	697	4182	1.625	.714	.313	.896	19000	943
1	111	825	936	5616	1.625	.904	.344	.886	22100	1160
2	111	686	797	4782	1.625	.904	.344	.886	18900	989
3	111	790	901	5406	1.625	.904	.344	.886	21300	1110

Table D—Continued

6′ span 3′9″ width. 1-3 mix.

Slab No.	Wt. per ft. of Width	Applied Breaking Load per ft. of width	Total Load per ft. of width	B. M.	Eff. Depth	% Steel	k	j	fs	fc
30	184	519	703	6327	1.875	.618	.295	.902	26900	1120
29	184	428	612	5508	1.625	.714	.313	.896	28200	1400
36	162	385	547	4923	1.4375	.805	.328	.891	27600	1360
26	206	750	956	8594	1.875	1.11	.373	.876	20800	1250
24	206	700	906	8154	1.9375	1.14	.377	.885	19100	1190
25	206	696	902	8118	1.6875	1.24	.389	.871	22000	1400
34	207	765	972	8748	1.8125	1.28	.394	.869	19800	1300
27	207	1306	1513	13617	1.75	1.33	.400	.867	32000	2140
35	207	864	1071	9639	1.75	1.33	.400	.867	22600	1510
43	173	592	765	6885	1.6875	1.38	.405	.865	16900	1150
44	165	577	743	6678	1.5625	1.49	.417	.861	17700	1270
22	164	455	619	5571	1.375	1.52	.420	.860	18800	1370
37	165	595	760	6840	1.500	1.55	.423	.859	19000	1390
21	164	510	674	7066	1.25	1.67	.435	.855	26300	2030
23	164	447	641	5769	1.25	1.67	.435	.855	21500	1650
31	164	493	657	5913	1.3125	1.78	.445	.852	18900	1510

8′ span 4′ width. 1-3 mix.

48	287	840	1127	13500	2.125	1.50	.418	.861	26800	1920
45	275	778	1053	12600	2.00	1.59	.427	.858	19200	1430
39	347	1212	1559	18700	2.625	1.60	.428	.858	15800	1240
46	287	697	984	11800	1.9375	1.64	.432	.856	18700	1420
42	332	1069	1401	16800	2.25	1.65	.433	.856	19600	1500
47	316	894	1210	14500	2.25	1.65	.433	.856	16900	1300
38	347	1231	1578	18900	2.50	1.69	.436	.855	16300	1350
40	347				2.50	1.69	.436	.855		
41	332	984	1316	15800	2.00	1.85	.451	.850	25000	2050

One of the 4 foot slabs

A 4 foot slab partially loaded

APPENDIX A

Tests upon the Materials used in Gunite Slabs.

Cement Tests.

Tests were run upon the composite brand of cement, composed of equal parts of Atlas, Alpha, Lehigh and Penn-Allen with the following results: All tests were performed according to the A. S. T. M. Standard specifications, serial designation C 9-17.

Specific Gravity—3.11.

Fineness—18.4% by weight residue on No. 200 sieve.

Initial set—3 hr. 30 min.

Final set—6 hr. 10 min.

Soundness—Steam test perfect. Six pats in moist closet 24 hrs., in steam bath 5 hrs. Pats remained firm and hard, and showed no signs of distortion, cracking, checking, or disintegration.

Tensile Strength of Briquettes.

	% H_2O	7 day			Ave.	28 day			Ave.
Neat	22	746	692	688	688	725	740	700	722
1-3 Standard Sand	14.2	246	236	242	241	319	309	303	310
1-3 Sand	12.0	163	106	100	123	165	159	151	158
1-2½ Standard Sand	13.2	280	286	295	287	370	355	350	358
1-2½ Sand	10.5	115	143	117	125	180	198	185	187

Sand Test.

Wt. per cu. ft. 98 lbs.

Specific gravity, 2.67.

Coloremetric.—

A 12 oz. graduated prescription bottle was filled to the 4½ oz. mark with the sand and a 3 per cent. solution of sodium hydroxide added until the volume of the sand and solution, after shaking amounted to 7 ozs. The bottle was shaken thoroughly and allowed to stand for 24 hours. Observations taken at this time showed the liquid above the sand to be clear, indicating a good quality of sand. There was only a slight trace of clay present.

Mech. Analysis of Sand
Tyler Sieves

Sieve Size	Size of opening	Per cent. of sample coarser than a given sieve
100 mesh	.0058	95.15
48 "	.0116	72.00
28 "	.0232	30.10
14 "	.046	15.55
8 "	.093	7.30
4 "	.185	3.05
⅜ "	.371	.80
¾ "	.752	0
1½ "	1.49	0

Fineness modulus—2.24

APPENDIX A—Continued

Steel Reinforcement.

Tension Tests of single strands of the Expanded Metal mesh were run upon a Riehle Universal Testing machine. The area was determined by weighing the sample and then computing the sectional area.

Tension Tests of Reinforcement

Spec.	Nominal Area	Weight lbs. per sq. ft.	Area Single strand	Yield Point Load lbs.	Lbs. per square inch	Max. load lbs.	Lbs. per sq. in.
U	.10			770	58800	920	69400
V	.10			790	59600	920	69300
W	.10			740	55800	940	70900
X	.10			760	57400	950	71600
Y	.10			780	58900	940	70900
Av.			.01325				
P	.15			830	58200	1030	72200
Q	.15			820	57600	1020	71600
R	.15			810	56800	1010	70900
S	.15			840	58900	1040	73000
T	.15			830	58200	990	69500
Av.		0.63	.01425				
K	.20			1020	56500	1330	73500
L	.20			1050	58200	1350	74600
M	.20			1050	58200	1350	74600
N	.20			1040	57600	1340	74200
O	.20			1020	56500	1320	73100
Av		0.774	.01805				
F	.25			1440	55900	1800	69800
G	.25			1480	57500	1840	71400
H	.25			1470	57100	1830	71000
I	.25			1460	56600	1820	70600
J	.25			1430	55500	1790	69500
Av.		.0935	.0258				
A	.30			1620	56400	2035	70800
B	.30			1650	57400	2050	71400
C	.30			1690	58800	2100	73100
D	.30			1730	60200	2140	74500
E	.30			1590	55400	2000	69600
Av.		1.15	.02875				
1	.40			2920	57500	3690	72600
2	.40			2900	57100	3700	72900
Av.		1.405	.0509				
3	.45			3480	58700	4300	72600
4	.45			3410	57600	4370	73700
Av.		1.575	.0593				
5	.50			3910	57800	4720	69600
6	.50			3980	58800	4750	70300
Av.		1.845	.0676				

CONCRETE SLABS

The following tables give the results of the tests on the two concrete slabs. The appendix A of this report gives the tests upon the cement, sand, and crushed stone used in making the slabs.

Slab No.	Thickness inches	Eff. Depth	St'l reinforcement	% Steel	Brk. Load lbs.	Equiv. unif. load	lbs. per sq. ft.	Age days	Remarks
32	2	1.4375	.251	1.45	5215	6950	309	27	Compression
33	2	1.50	.129	0.77	3331	4440	197	27	failure

Span 6′ width 3′9″ Mix 1-2-4

n—15

Slab No.	Wt.per ft. width	Test load per foot width	Total load per ft. width	B.M.	Eff. Depth	% Steel	k	j	fs	fc
32	163	464	627	5650	1.4375	1.45	.477	.842	18600	1130
33	162	296	458	4120	1.50	0.77	.379	.874	22600	923

In both of the above slabs the compression failure was followed by tension failure. In slab No. 32, 10 strands were not broken while 10 strands showed reduction of area. In slab No. 33 all but two strands were broken.

Crushed Stone.

Crushed Stone used in making slabs No. 32 and 33. Weight per cu. ft. 86 lbs.

Mechanical Analysis of Stone
Tyler Sieves

Sieve Size	Size of opening	Per cent of Sample coarser than a given sieve
100	.0058	98.1
48	.0116	98.0
28	.0232	97.9
14	.0460	97.7
8	.0930	97.0
4	.1850	90.4
⅜	.371	50.5
¾	.742	0.
1½	1.49	0.
		629.6

Fineness Modulus—6.30

Concrete Slabs No. 32 and 33.

Size of slab 7′x3′-9″ x 2″.

Vol. of two slabs—8.76 cu. ft. say 9.00 cu. ft. 1-3 cu. yd.

A 1-2-4 mix requires 1.57 bbls. cement, 0.44 cu. yd. sand, and 0.88 cu. yd. stone.

Slabs require 1-3 of above quantities or 0.52 bbls. cement, 0.15 cu. yd. sand and 0.30 cu. yd. stone. Used two bags of cement, 4½ cu. ft. sand, and 9 cu. ft. stone with 15.3% water.

Cement, sand and stone were thoroughly mixed dry and then water added. Mixed and placed in forms, tamping thoroughly.

Slabs 32—Steel 0.25 sq. in. per ft. of width.

Slab 33—Steel 0.15 sq. in. per ft. of width.

Compression Test of Cylinders.

Two cylinders were made Feb. 18, 1920, of the same Cement, Sand and Stone that was used in Slabs Nos. 32 and 33. Mix 1-2-4.

Volume of two 8″ diam. by 16″ cylinders, .035 cu. yd.

Quantity of Cement—21.6 lbs.

Quantity of Sand—50.9 lbs.

Quantity of Stone—89.44 lbs.

Per cent of water, 15.3%.

These cylinders were tested March 17, 1920, at the age of 28 days.

No. 1—Max. Load 157,000 lbs.

No. 2—Max. Load 145,000 lbs.

302,000

Av. 151,000.

Stress 3010 lbs. per sq. in.

Respectfully submitted.

M. O. Fuller

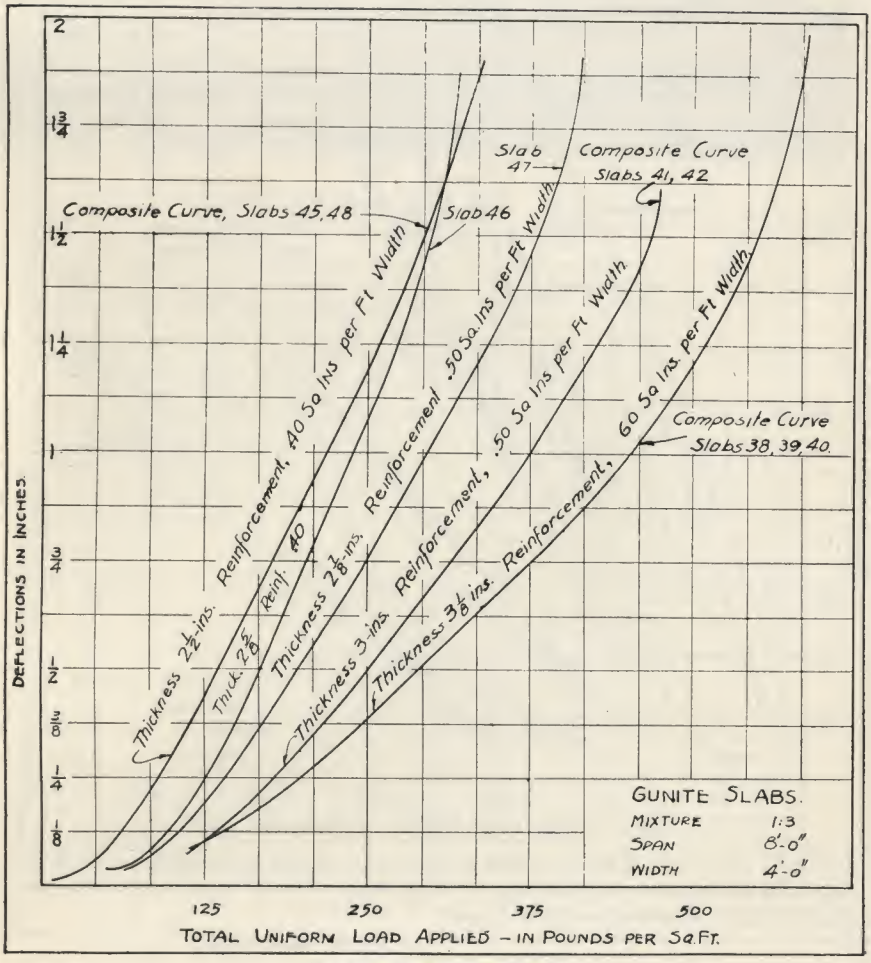


Fig. 1 Referred to on Page 17.

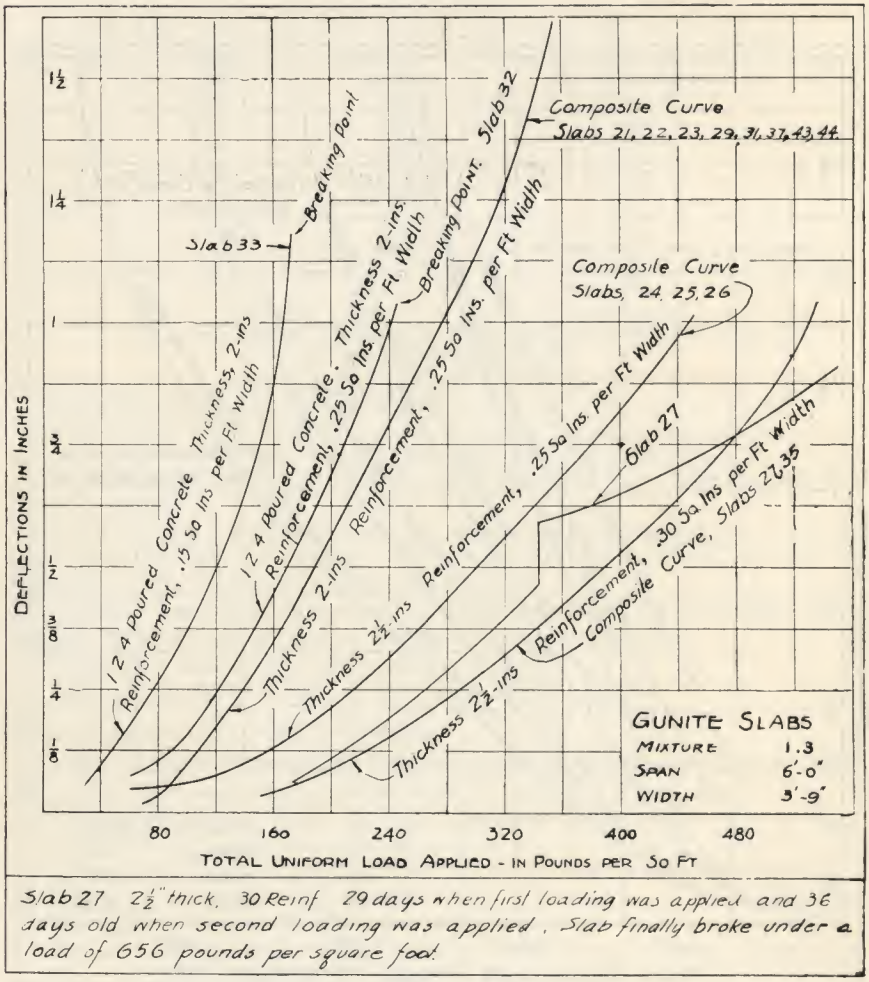
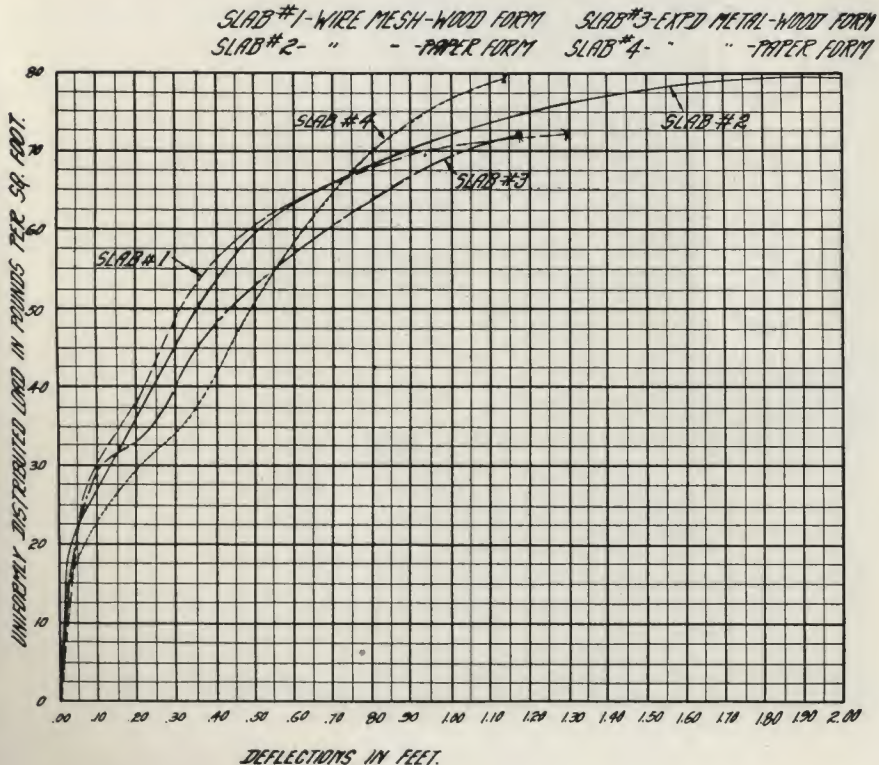


Fig. 2 Referred to on Page 17.

ADDENDUM



In addition to the preceding report from Lehigh University the Cement-Gun Co., Inc. refers you to the above curves and photograph illustrating the deflections in four slabs recently tested by the New York-New Jersey Tunnel Commission to determine the value of "Gunite" for walls in the building of the fan chambers of the Holland Tunnel.

These slabs were three inches thick, eighteen foot span, and reinforced at three-quarter inch from both the upper and lower faces with a layer of reinforcing mesh three-tenths square inch of steel per foot of width.

Four slabs were tested, breaking at an average live load of seventy-five pounds per square foot, and with an average deflexion of fifteen inches before failure. All failures were due to insufficient reinforcement.

As a result of these tests "Gunite" has been specified not only for these walls, but also for shaft linings, and for covering brick and tile partitions.

The above photograph represents slab No. 40, page 21, at 24 months after the load was applied. Note deflection of 2″ with no increase in the size or number of cracks.

GUNITE

CEMENT-GUN COMPANY INC.

Allentown, Pa.

NEW YORK OFFICE:
30 CHURCH STREET

BULLETINS